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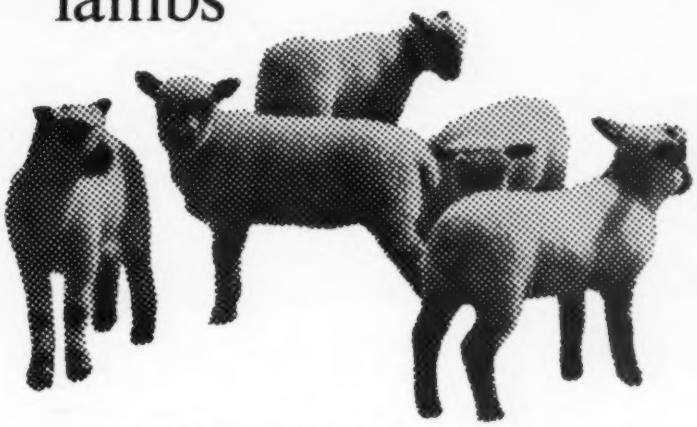

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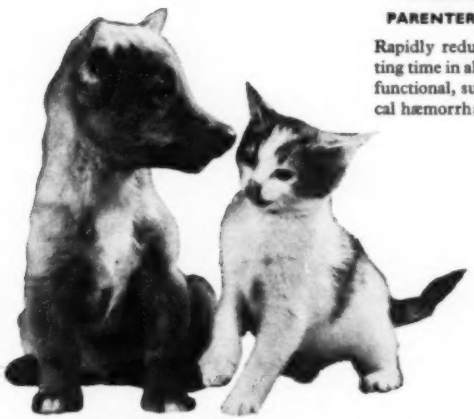

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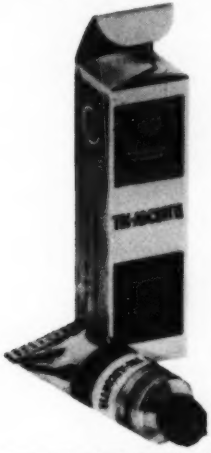

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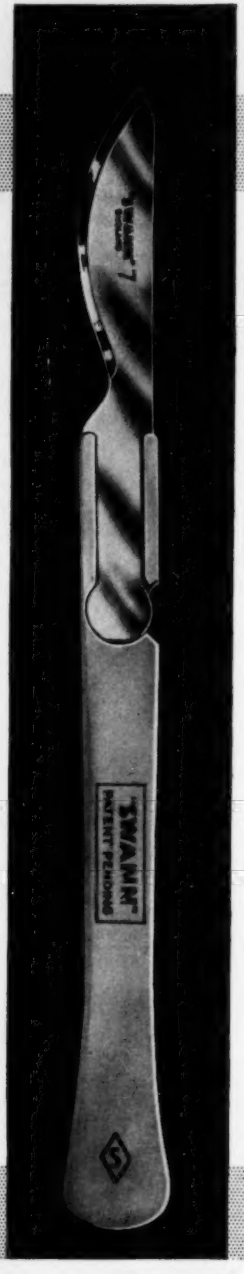

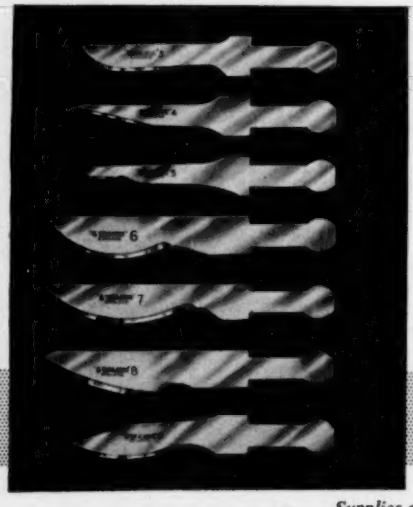

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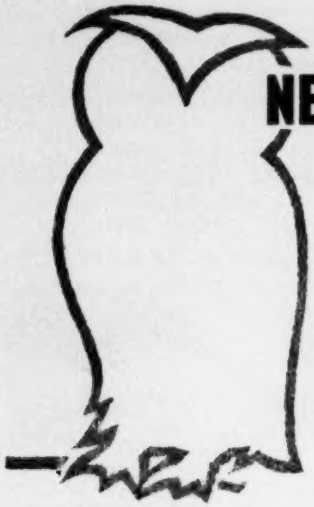

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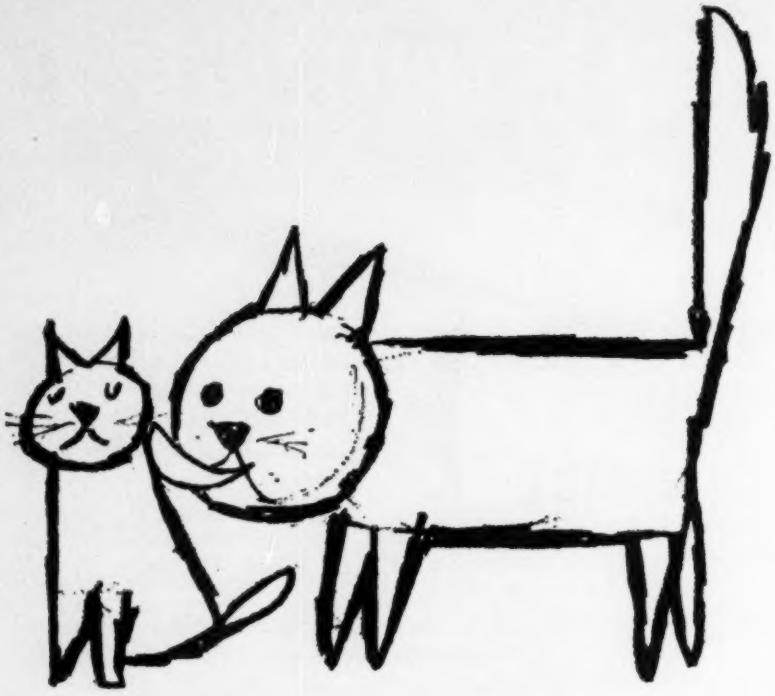

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A REVIEW OF STUDIES ON THE GROWTH RATE OF THE HORSE

By D. A. Green

Department of Animal Husbandry and Veterinary Hygiene, Royal Veterinary College, University of London

Considerable research into the rate of growth of horses has been carried out in various countries, with records of statistics under different environmental conditions. Much of the published work reviewed here was carried out in Europe, Russia and America but unpublished records of growth in animals bred at Army remount establishments in India and Pakistan were also made available (Director of Remounts, Veterinary and Farms Dept., Army H.Q., India, and Director of Remounts, Veterinary and Farms Dept., Army H.Q., Pakistan, personal communications).

The object of the present survey is to review some of the factors which influence growth in horses, and to make a comparison of growth-rate curves for different breeds of horses under various ecological conditions, where the plane of nutrition was at an adequate level for normal growth requirements. One study is quoted where the plane of nutrition was known to be inadequate.

Allowing for the variations in individual animals, it seems possible that an average height growth rate during various periods between birth and maturity might be formulated.

FACTORS IN GROWTH AND MATURITY

The many factors affecting live-weight increase and skeletal development have been examined by numerous workers; in particular the plane of nutrition, vitamin and mineral requirements, and the seasonal variations in climatic conditions, have been studied.

The effect on growth in cattle has been studied in conditions where the plane of nutrition was known to be inadequate (Pomeroy, 1955); it was found that live-weight gain was arrested, but not skeletal growth. Dawson, Phillips and Speelman (1945), in a study of growth of horses under range conditions in western America, also found that where growth in height and weight up to five years was adversely affected owing to inadequate nutrition, height was affected less than weight.

In this country Hammond (1952) studied the effect of prenatal influence on postnatal growth, using reciprocal crosses between Shire horses and Shetland ponies. Similar studies were carried out by Flade (1957*a*) who states that maternal influence is greater particularly as regards birth weight, the paternal influence becoming increasingly stronger in the course of the first two years'

growth, although even at the end of that time it is only about 70 per cent of the dam's.

The time of year at which foaling takes place influences the birth weight and also the growth-rate curve. Halász & Hamori (1951) analysed statistics relating to 513 Kisbér half-bred foals using records of withers height and measurements of chest and cannon bone circumference at weaning and at one, two, and three years of age. This analysis showed that autumn foals had developed to a greater extent than spring foals, for although at weaning the body measurements of autumn foals were smaller, the reverse was the case at one, two, and three years of age. A similar study was carried out by Lohman and Marinic (1952) at the Lipik and Kutjero state studs. Data were obtained on first-year growth of 90 autumn-born foals and 184 spring foals. At both studs the birth weight of foals born in the spring was greater than that of those born in the autumn. There was no appreciable difference in live-weight gains up to nine months, after which time foals born in the autumn and weaned in the spring recorded the greater gains in weight.

Jordão & De Camargo (1950) published the results of an extensive study of the measurements of Mangalarga horses raised on an experimental farm at Coudelaria Paulista. The statistics relate to 143 foals, 74 males and 69 females, during a period from 1937 to 1949. From the examination of various factors which might influence the size of the foal at birth these authors concluded that neither the age of the mare nor the age of the stallion had any effect on the height of the foal at birth. When the height at birth was considered in relationship to the year of birth their analysis did not reveal any significant variation during the different years. They did conclude, however, that births during the months of May to September when the gestations were shorter produced foals of smaller stature than did births from October to December.

From these findings the authors state that a significant correlation was established between the height of the foal at birth and the period of gestation. In these studies weight was only recorded at 60 months to provide a comparison between mares and stallions at maturity.

EFFECT OF FEED SUPPLEMENTS ON GROWTH RATE

The use of antibiotics as feed supplements for young horses has been investigated on a limited scale. Their extensive use for the promotion of growth in food animals is based on increase in live weight rather than on any improvement in skeletal development.

Berthelon (1953) fed a supplement of chlortetracycline, penicillin and vitamin B_{12} to foals six to eight months old. Using the height measurement for comparison he was unable to demonstrate any benefit from the supplement.

Taylor, Gordon & Burrell (1954) studied the effect of a diet supplemented by aureomycin hydrochloride on thoroughbred foals, using live-weight gain as the factor for comparison. Their results showed a significant increase in growth rate during supplementation, while a fall in growth rate occurred when the supplement was withdrawn. During this experiment radiographical

examination of the metacarpus and fetlock was carried out periodically, but no alteration in bone development was discernible during the period of supplementation.

Recently, Henricson (1960) fed a supplement of oxytetracycline hydrochloride to colts of the North Swedish breed from weaning up to one year of age. His conclusions were that this supplement had no demonstrable effect on the growth rate as measured by comparison of weight, body length and height at withers.

PERIODS OF INTENSITY OF GROWTH

Prenatal growth in the foal is most intense during the latter half of pregnancy, and at birth a relatively advanced stage of development has been reached in comparison with other domesticated animals.

The periods of intensity of growth from birth to maturity appear to be similar under different climatic conditions. In Russia it was found that the period of greatest intensity was during the first month after birth, with a second intense phase between weaning and 12 months of age, and a third phase after reaching puberty (Hitenkov, 1954). Thereafter, growth continued at a slow rate up to maturity.

Mañcić (1954), in Yugoslavia, recorded growth figures for Lipitsa foals in three state studs and found that growth was most intense during the first month after birth. Tabulation of separate figures for males and females in respect of height at withers, chest and cannon bone circumferences, and live weight showed that the increases recorded for males were greater than those for females as regards height and weight. The same differences between the sexes did not obtain for chest and cannon bone measurements.

Kreiner (1954), in Poland, studied the development of Poznan foals during the first year of life and found that various stages of development could be differentiated. The greatest changes occurred during the first and second months of life, with somewhat smaller changes during the fourth and sixth months and at the end of the first year.

Roždestvenskaja & Grigorjev (1957) found a breed variation of intense growth phases from observations on male foals from birth to 12 months. Russian draft horses and Orlov trotters exhibited intense growth phases first from birth to three or three and a half months, secondly from four to seven or eight months, and thirdly from eight or nine months to twelve months. By contrast, Budennyi horses had intense growth phases from birth to two months, secondly from three to seven months and thirdly from seven months to twelve months.

This would appear to confirm the findings of Dawson *et al.* (1945) that there was no evidence, under the conditions of their work, that draft horses matured more rapidly than light horses, as has sometimes been claimed (Gay, 1932; Harper, 1913).

PROPORTIONAL GROWTH RATES OF BODY PARTS

The relatively advanced stage of development of the foal at birth has already been referred to. In particular, the postnatal increase in length of the bones

of the limbs is fractional compared with the development of other parts of the body.

The work of Isaachsen (1933) on the proportional development of the foal at birth provides detailed statistics for the various body parts presented as a percentage of the measurements and weight attained at maturity.

Krüger (1939) studied the rate of growth in length of body parts in light and heavy horses. Using a photographic method of measurement, he found that the metacarpus and metatarsus had completed growth at the end of the first year, the digital bones, radius, ulna, tibia and fibula at two years old. All other parts of the skeleton continued growth until the fourth or fifth year of life. It was also observed that the joint angles did not show any recognizable changes during development.

Ščekina (1950) recorded statistics of growth for selected groups, "Kult-group", of the best types of young stock of Don and Budennyi breeds from birth to five years, using measurements of height, girth and metacarpus. These groups were reared under a partly artificial and a partly herd system. While under the herd system, adequate measures were adopted for protection from the rigours of the climate, and a generous diet supplement of concentrates and hay was provided.

Separate figures are given for colts and fillies of each breed. The colts of both breeds achieved a slightly greater final development in height and metacarpus. However, the mean girth development of fillies of the Don breed proved a little better than that of the colts. In the Budennyi breed, girth development of colts and fillies was, on average, almost identical.

COMPARATIVE GROWTH CURVES

Growth curves from birth to 18 months for height of Arabs, thoroughbred English horses and donkeys at remount depots in Pakistan demonstrate

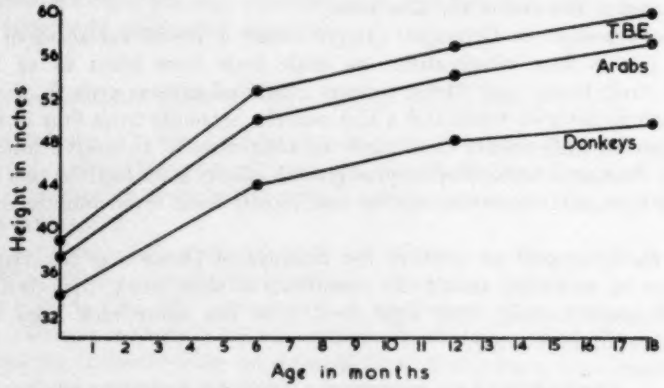

Fig. 1. Comparative growth curves for thoroughbred English (T.B.E.) horses, Arabs and donkeys showing height in inches from birth to 18 months at remount depots in Pakistan.

identical growth phases between six and twelve months, and equal growth for the two horse breeds from 12 to 18 months (Director of Remounts, Veterinary and Farms Department, Pakistan, personal communication) (Fig. 1).

Statistics published by Ščekina (1950) of growth of young stock of Don and Budennyi breeds at the S.M. Budennyi stud in Russia are shown in Figs. 2 and 3. Height gains in inches are shown from birth to maturity. Growth curves for fillies follow closely those for colts, though height at maturity of the fillies was on average 1·6 inches less than that of the colts of the Don breed, and 1·4 inches less in the Budennyi breed.

When Figs. 2 and 3 are compared, it can be seen that the growth from birth to 18 months in each case totals 20 inches, and in Fig. 1 the thoroughbred English horses show an identical height gain for the same period.

The total height gain up to 60 months was an average of 24·4 inches for Budennyi, and 24·2 inches for Don colts.

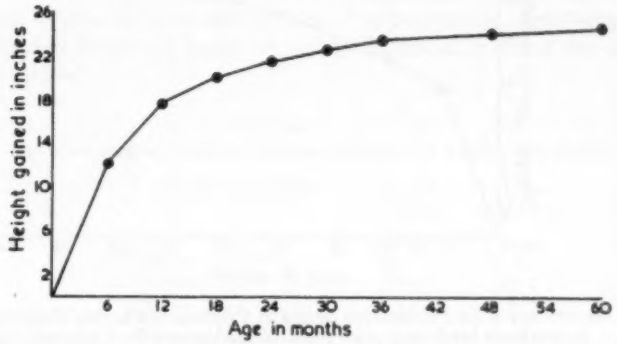

Fig. 2. Growth curve for Don colts at S.M. Budennyi stud in Russia, showing height gains in inches from birth to 5 years (data of Ščekina, 1950).

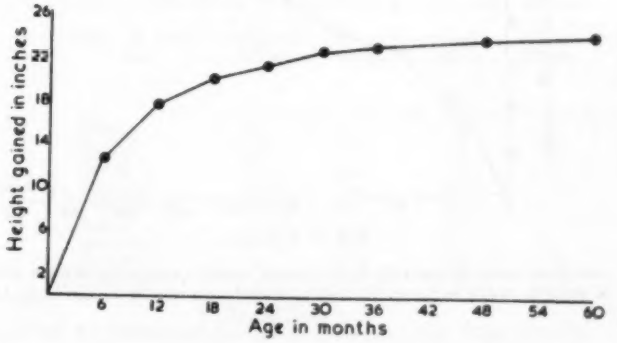

Fig. 3. Growth curve for Budennyi colts at S.M. Budennyi stud in Russia, showing height gains in inches from birth to 5 years (data of Ščekina, 1950).

The growth curve for Mangalarga horses, from the statistics published by Jordão & De Camargo (1950) which give the mean figures for both sexes, is shown in Fig. 4. It will be seen that while the total average growth of 24·1 inches is very close to the total average growth figures of Russian Don and Budennyi breeds, after the first six months the Mangalarga developed more slowly. The growth in the first two years was 20·5 inches against 21·2 inches and 21·6 inches by the Don and Budennyi, with the most striking comparison between six and twelve months, namely 3 inches for Mangalarga against 5·2 inches and 5·6 inches for the Russian breeds and 4 inches for Arabs and thoroughbred English horses in Pakistan (Fig. 1). Growth in the first six months, however, was greater than for the Russian breeds but similar to the thoroughbred English horses in Pakistan.

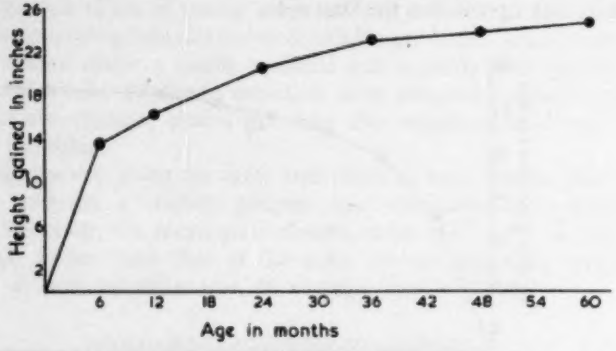

Fig. 4. Growth curve for Mangalarga horses at Coudelaria Paulista showing height gains in inches from birth to 5 years (data of Jordão and De Camargo, 1950).

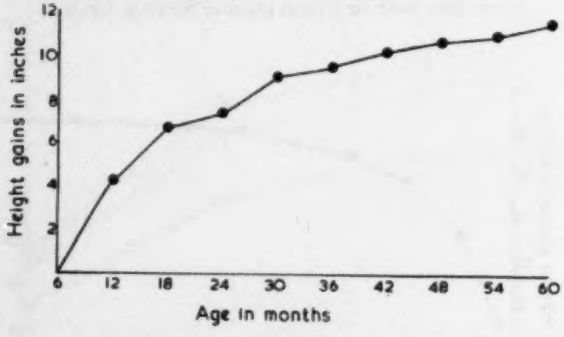

Fig. 5. Composite growth curve for horses under western range conditions showing flattening of growth curve between 18 and 24 months on winter range keep (data of Dawson *et al*, 1945).

The study of growth rates by Dawson *et al.* (1945) on horses under range conditions covered 297 horses of four different breeds. Two draft breeds and

two light breeds were selected, and separate figures for males and females are tabulated and also shown as comparative growth curves. These demonstrate normal growth between 6 and 18 months, at which age they were put on winter range keep on a low nutritional plane, and the growth curve flattens out. With the advent of the summer grazing, growth resumes its upward curve at a somewhat greater rate than might be expected between 24 and 30 months when an adequate nutritional level is maintained throughout the year. In Fig. 5 a mean of the statistics for colts and fillies has been averaged for the four breeds, to show the flattening of the growth curve while on winter range keep and for comparison with the steady upward growth curves in Figs. 2, 3, and 4.

ABSOLUTE MEASUREMENTS OF HEIGHT INCREASE DURING DEVELOPMENT

In Tables I and II absolute measurements of height gains have been tabulated for comparison of growth rates and phases. The remarkable similarity of the figures for different breeds of horses in widely separated parts of the world is clearly demonstrated.

TABLE I

HEIGHT GROWTH DURING EARLY INTENSE PHASES FOR DIFFERENT BREEDS

Breed	*Country in which bred*	*Birth–6 Months*	*6–12 Months*	*12–18 Months*
		Inches	*Inches*	*Inches*
Budennyi	Russia	12	5·6	2·4
Don	Russia	12·4	5·2	2·4
Mangalarga	Brazil	13·32	3·0	—
Thoroughbred English	Pakistan	13·25	4·0	2·75
Arab	Pakistan	12·5	4·0	2·75
Country bred	India	—	3·5	2·0
Donkeys	Pakistan	10	4	1·75

TABLE II

YEARLY HEIGHT GAINS UP TO FIVE YEARS FOR DIFFERENT BREEDS

Breed	*Country in which bred*	*Birth–12 Months*	*12–24 Months*	*24–36 Months*	*36–60 Months*	*Total birth to 60 Months*
		Inches				
Budennyi	Russia	17·6	4	1·6	1·2	24·4
Don	Russia	17·6	3·6	1·8	1·2	24·2
Mangalarga	Brazil	16·32	4·2	2·0	1·6	24·12
Thoroughbred English	Pakistan	17·25	—	—	—	—
Arab	Pakistan	16·5	—	—	—	—
Country bred	India	—	3·45	2·1	—	—
Hafling	Germany	—	3·6	2·0	1·2	—
East Prussian	Poland	—	3·6	2·8	1·56	—
Mecklenburg	Poland	—	3·64	1·6	1·6	—

GROWTH EXPRESSED AS PERCENTAGE OF THE FINAL MEASUREMENTS AT MATURITY

As an alternative to consideration of absolute measurements, the rhythm of

growth can be expressed in terms of percentage of the final measurements of the fully grown animal. It has been established by a number of workers that the height of the foal at birth corresponds to approximately 60 per cent of the ultimate height at maturity.

Hesse (1957), in a comparative study of the development and growth of small horses, compares the percentage growth of the small breeds with that of the German Rhineland (cold-blood) horses. The tabulated results are reproduced in Table III, demonstrating only minor differences in the development rate between the small and the cold-blood horses.

TABLE III

DEVELOPMENT OF SMALL BREEDS COMPARED WITH GERMAN COLD-BLOOD HORSES (FROM HESSE, 1957)

Comparative measurements	*Breed*	*Measurements in percentage of final measurements*		
		After 6 Months	*After 12 Months*	*After 24 Months*
Height at withers	Rheinisches-dt.Kaltblut	83·1	90·6	96·9
	Norwegian	84·2	91	95
	Icelandic	86	90·9	95·5
	Haflinger	—	88·9	92·2
	Shetland pony	86	92·9	99·1
Depth of chest	Rheinisches-dt.Kaltblut	70·9	83·5	94·9
	Norwegian	76·6	86·2	93·4
	Haflinger	—	81·1	94·4
	Icelandic	73·2	83·3	90·9
	Shetland pony	81	91·3	100
Circumference of cannon bone	Rheinisches-dt.Kaltblut	71	81·1	90·2
	Norwegian	84·4	94·4	100
	Haflinger	—	92·8	99·2
	Icelandic	88·2	94·7	100
	Shetland pony	82·8	87·6	96·6

TABLE IV

BODY DEVELOPMENT OF THE ARAB HORSE IN POLAND COMPARED WITH EAST PRUSSIAN HORSES AND MECKLENBURG COLD-BLOOD HORSES (FROM FLADE, 1958)

Age of animal	*Measurements as percentage of final measurements*		
	Arab ($n = 20$)	*East Prussian* ($n = 10$)	*Mecklenburg-Kaltblut* ($n = 41$)
(a) *Height at withers*			
1 year	86	88	89
2 years	95	93	95
3 years	98	98	98
5 years	100	100	100
(b) *Chest girth*			
1 year	77	78	80
2 years	89	89	92
3 years	96	97	99
5 years	100	100	100
(c) *Cannon bone circumference*			
1 year	83	81	84
2 years	92	91	92
3 years	96	96	100
5 years	100	100	100

n = number of animals

Flade (1958) compares the development of the Arab bred in Poland with East Prussian horses and also with Mecklenburg cold-blood animals. In addition to absolute measurements, the results are expressed as percentages of final measurements and are reproduced in Table IV. Similarly, percentage weight increases were recorded and these figures are reproduced in Table V.

TABLE V

INCREASE IN WEIGHT DURING GROWTH OF THE ARAB HORSE IN POLAND COMPARED WITH EAST PRUSSIAN HORSES AND MECKLENBURG COLD-BLOOD HORSES (FROM FLADE, 1958)

Age of Animal	*Weight as percentage of mature weight*		
	Arab	*East Prussian*	*Mecklenburg-Kaltblut*
Birth	10·5	9·0	8·0
1 year	40·0	54·0	57·0
2 years	74·0	76·0	76·0
3 years	86·0	87·0	91·0
5 years	100	100	100

DISCUSSION

The similarity of growth rhythm in horses of various breeds in widely separated geographical locations is evident from the published statistics of absolute measurements, and also from the comparison of development expressed as a percentage of the final measurements of fully grown animals.

The majority of the studies carried out on the growth and development of horses provide statistics of: (a) height at withers, (b) chest girth measurement, (c) cannon bone circumference and (d) live weight. Increases in measurement under these headings are recorded at various intervals. A satisfactory and complete follow-through of growth study from date of birth to maturity can only be achieved when sufficiently large numbers of animals are maintained for the whole of this period. These conditions do not often exist, as animals are usually sold or dispersed at a comparatively early age, so that in many cases records can only be obtained for the first year or two of life. It is essential that relatively large numbers of any breed be included in a growth-rate study, to provide a reliable average. The individual variations in rate of development of horses are such that the use of small groups would inevitably produce inconsistent and variable results.

The rhythm of growth is not apparently affected greatly by different systems of management or environmental conditions, provided young stock are protected from the rigours of climatic extremes and an adequate nutritional plane is maintained throughout. The rate of progress to maturity may be affected by differing stud or herd conditions, but so long as adequate nutrition is provided final development will not be affected. Thus, the growth rate curves in different studs may vary slightly in rate of ascent, but the steady upward progression should be maintained.

The most reliable and consistent standards of development appear to be height at withers and bone development as measured in terms of the circumference of the metacarpal bones. Chest girth measurements are much more

variable since they depend to a great extent on general physical condition, and can therefore only be regarded as of limited importance as a measure of the progress of growth in the immature animal. At maturity, the importance of this measurement is obvious.

Live-weight gain is also very variable and affected by many influences. It is more a measure of condition than of growth development in the horse. Putting horses to work at an early age will result in more rapid muscular development than if animals remain unbroken at pasture. In some breeds the mares may be sent to stud at a comparatively early age, and the onset of pregnancy would invalidate weight recordings as an index of growth. Under ideal conditions for growth studies, however, records of live weight should be maintained.

It would appear desirable that a system or pattern for records of growth in horses should be standardized. Weight and measurements should be recorded at birth, and preferably at three-monthly intervals through the intense phases of growth up to two years. Thereafter, measurements at six or even twelve-monthly intervals to maturity would suffice. Although it is generally accepted that skeletal growth is completed at five years of age, individual horses do develop beyond this age, so that to provide the complete picture, measurements at six years old would be valuable.

ACKNOWLEDGEMENTS

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INVESTIGATION INTO THE INCIDENCE AND CAUSES OF INFERTILITY IN DAIRY CATTLE—INFLUENCE OF KALE FEEDING, MILK PRODUCTION AND MANAGEMENT FACTORS ASSOCIATED WITH "FARMING INTENSITY"

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In recent years milk production in dairy herds has risen considerably, not only because of increased production per animal, but often also because more animals can be carried per acre as the result of improved pasture management. This increased level of "farming intensity" is liable to impose an added strain on the metabolism of the animal and any deficiency or imbalance in the diet is more likely to be exposed. Schaetz (1956) stated that sterility associated with stress is a fairly common condition in cattle and is associated with hyperfunction of the adrenal cortex as well as with other hormonal imbalances, and Hinze (1959) regards certain conditions of stress as liable to cause infertility. Williams (1960) has shown that herds that had been recently established had a lower conception rate than other herds and considers that stress could play a part in this. The literature on the effect of milk production on fertility is conflicting. Lewis & Horwood (1950) found that cows beginning at a high level of production were not bred as early nor did they conceive as readily as those breeding at lower levels. Other authors have made similar observations (Müller, 1954; Ragab, Asker & Hilmy, 1956). Boyd, Seath & Olds (1954) found that milk yield had no effect on services per conception; Currie (1956) obtained similar results. Although detailed literature is limited, the belief is fairly widely held that modern intensive farming methods may disturb fertility.

Hignett (1950) noted that in a small survey using artificial insemination records, herds with a conception rate below 20 per cent in the months April–June came from farms with a higher proportion of leys, which were both limed and slagged to a greater extent than on farms with herds which had a conception rate above 80 per cent. Later Hignett (1952) described a type of herd infertility apparently associated with nutritional factors which appeared to be more common in neglected farms recently taken over by progressive farmers.

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The adverse effect of heavy kale feeding on the production of viable lambs was described by Shand (1952) and there is a widespread feeling that kale is associated with poor fertility in cattle.

It was therefore felt that these aspects of farm management warranted further investigation as a possible cause of infertility. The level of "farming intensity" or production cannot be satisfactorily assessed by one single figure because so many factors are involved. In this paper an attempt has been made to determine the level of "farming intensity" by considering the effect of five basic features: milk production per animal, milk production per acre, livestock grazed per acre, the proportion of temporary leys and the proportion of kale grown.

The fact that known causes of infertility might obscure the picture was borne in mind, and a comprehensive examination of the herds under investiga-

TABLE I

RELATIONSHIP BETWEEN CERTAIN FARM FACTORS AND CONCEPTION RATE (DARTINGTON HALL)

Farm factor		*Friesians*		*Ayrshires*		*Guernseys*		*South Devons*	
		No. of 1st inseminations	*CR*	*No. of 1st inseminations*	*CR*	*No. of 1st inseminations*	*CR*	*No. of 1st inseminations*	*CR*
Gallons milk/cow	Up to 450	–	–	36	61·1	137	59·1	998	67·7
	451 – 550	25	80·0	86	65·1	298	58·7	1,584	64·8
	551 – 650	518	57·3	440	60·7	527	57·5	1,555	65·5
	651 – 750	369	61·5	260	55·4	353	57·5	827	66·3
	751 – 850	960	59·8	265	50·2	136	55·9	243	61·7
	Over 850	1,186	61·0	14	78·6	28	53·6	154	63·6
	Total	3,058	60·5	1,101	57·5	1,479	57·7	5,361	65·6
"Livestock"/100 acres of grass	Up to 20	159	58·5	17	64·7	18	66·7	770	66·5
	21 – 30	789	60·3	184	59·2	335	56·1	2,831	65·4
	31 – 40	1,054	60·0	421	56·5	529	59·2	1,100	65·4
	41 – 50	647	59·8	240	60·4	361	59·3	432	67·1
	Over 50	409	64·3	239	54·4	236	53·4	250	64·4
	Total	3,058	60·5	1,101	57·5	1,479	57·7	5,383	65·7
% temporary grass (up to 5 years)	Less than 30	1,127	59·5	257	55·6	496	55·4	2,067	66·2
	31 – 70	1,296	60·6	572	57·9	532	58·5	2,641	65·2
	Over 70	635	62·0	272	58·5	451	59·2	663	66·5
	Total	3,058	60·5	1,101	57·5	1,479	57·7	5,371	65·7
% kale of total acreage (winter fertility only)	No kale	226	64·2	11	45·5	55	56·4	537	67·2
	0 – 3·0	345	62·3	24	50·0	35	57·1	1,186	65·6
	3·1 – 6·0	562	61·0	70	57·1	144	57·6	982	64·5
	6·1 – 9·0	405	70·1	248	56·0	161	53·4	306	59·2
	9·1 – 12·0	184	54·3	116	63·8	239	57·7	105	57·1
	Over 12·0	231	56·3	181	60·2	161	64·6	25	48·0
	Total	1,953	62·3	650	58·3	795	58·1	3,141	64·5

$$CR = \text{conception rate} = \frac{\text{number of non-returns at 5 months}}{\text{number of first inseminations}} \times 100$$

ion had previously been made. In most of these herds artificial insemination only was used. The incidence of *Brucella abortus* and *Vibrio fetus* infections and their effect on fertility in these herds was negligible (Boyd & Reed, 1960). In an analysis of normal fertility variations the animal's age and the birth of twins or an abortion in the previous gestation were shown to influence fertility (Boyd & Reed, 1961*a*). Examination of the factors affecting the semen and conditions of insemination revealed that the age of the semen and the calving service interval had an appreciable effect on fertility (Boyd & Reed, 1961*a*). One bull in use during the time of the observations had a low conception rate, but no other factors could be observed that were related with fertility.

A preliminary survey on the effect of farming intensity had been carried out which showed that there were breed differences within the "intensity factors" studied, even as regards the amount of temporary grass and kale grown (Table I). The "intensity factors" studied showed no consistent effect on fertility. The impression was gained that Friesians were less affected by "farming intensity" than Ayrshires and Guernseys, the two latter breeds appearing to have poorer fertility in herds with high milk yields and levels of stocking. The effect of kale feeding on winter fertility was confusing; South Devon and Friesian herds in which large quantities of kale were fed showed poor fertility whereas in Ayrshires and Guernseys high levels of kale feeding appeared to be associated with good fertility. The amount of temporary grass on the farm had no effect on fertility in any breed.

Partly because of the inconclusive nature of the first survey, a second survey was planned in Somerset. In this survey, which forms the main part of this paper, only National Milk Recorded herds were included so that reliable details would be available for each cow. To avoid breed differences the survey was confined to Friesians, the dominant breed in the area. More data were also included from the limited number of herds from Dartington in the first survey which contained only Friesians and were National Milk Recorded.

MATERIAL

A hundred National Milk Recorded British Friesian herds in Somerset, each consisting of at least 20 cows and heifers of breeding age, were selected. In most herds artificial insemination only was used, but a few in which natural service was used on heifers only were included so that sufficient herds could be obtained.

At Dartington Hall 45 National Milk Recorded British Friesian herds of at least 15 cows and heifers of breeding age, for which artificial insemination only was used, were studied.

METHODS

Measurement of "Intensity Factors"

As the results from the survey in Somerset form the major part of this paper the methods used there will be given, with a note on differences at Dartington. The material was collected for the twelve-month period from 1st April 1957

to 31st March 1958 in Somerset and from 1st April 1956 to 31st March 1957 at Dartington.

Livestock. Three measurements of stock were taken:

(a) For the purpose of determining milk yield per cow, and cows per acre of kale, only those animals recorded as lactating for the period concerned were included. Where an animal was in milk for only part of the time, then only that fraction was counted. At Dartington the figure taken was the number of animals in the milking herd, including dry cows, at the time of the visit.

(b) A second measurement, comprising all the recorded adult animals plus all inseminated heifers, was designated "adult" cattle.

(c) A third measurement ("total stock") included all the cattle on the farm over twelve months old and to this were added all adult sheep, each of which was regarded as one-sixth of a cow unit. At Dartington the total number of cows plus adult sheep (one-sixth of a cow unit) were designated "livestock".

Milk. The annual yield was calculated from the monthly figures of milk sold wholesale and retail, together with an estimate of the amount required for household use and for feeding calves.

Acreage. Acreage figures for the whole farm, the total grass, the leys up to three years and up to five years, the pasture seven years and over, and the acreage of kale, were recorded.

From these basic figures, yields per animal and per acre, rates of stocking per acre and the percentage of different crops grown were calculated. In addition further miscellaneous information was collected relating to silage feeding, strip grazing, use of natural service, date of foundation of herd, purchase of individual animals, housing and milking conditions.

Measurement of Fertility

Conception rate was defined as the percentage of first inseminations which produced pregnancies. It has been necessary to take account of some factors known to influence fertility in this material. The three main ones are the number of gestations (age of cow), the calving service interval and the age of semen used. The expected percentage of conceptions for the different combinations of these factors shown in Table II is based on a previous paper (Boyd & Reed, 1961*b*). A small number of cows whose fertility had been affected by a preceding abortion or twin calving, or which had been inseminated with semen from one bull of known low fertility, were previously excluded. By using the values in this table it was possible to calculate a herd conception rate corrected for these three factors by the following method.

For each herd the number of cows in any of the fifteen categories of the table was called n_i where i may take the values from 1–15. The expected percentage of conceptions in each category was called p_i. The expected number of conceptions in each category was obtained by multiplying n_i by p_i and the sum of these products gave the expected number of conceptions for the herd. The deviation (d_i) for each farm was obtained by subtracting the expected

number of conceptions from the observed number of conceptions. Similarly the deviation for different levels of "intensity factors" was obtained by finding the sum of d_i for all farms at succeeding levels of the factor being studied and dividing it by the total number of animals. This was added to the general mean (61·2 per cent) to give a "corrected" conception rate for the level of the factor.

TABLE II

EXPECTED PERCENTAGE OF CONCEPTIONS FOR ANIMALS WITH DIFFERENT CATEGORIES OF AGE, CALVING SERVICE INTERVAL AND AGE OF SEMEN USED, BASED ON A PREVIOUS PAPER (BOYD AND REED 1961*b*)

Age of semen	*Calving service interval*	*Age of cow (No. of gestations)*		
		Heifers	*1–6*	*Over 6*
		Conception rate %		
1st and 2nd day	Over 60 days	—	69·38	57·54
	Up to 60 days	—	56·46	43·69
	Heifers	63·25	—	—
Over 2nd day	Over 60 days	—	58·32	45·58
	Up to 60 days	—	44·48	32·39
	Heifers	50·08	—	—
Deep frozen	Over 60 days	—	51·60	38·89
	Up to 60 days	—	37·91	26·69
	Heifers	44·88	—	—

TABLE III

RELATION BETWEEN QUANTITY OF KALE GROWN AND FERTILITY (ONLY WINTER FERTILITY OF COWS CONSIDERED)

% Kale of total farm acreage	*Somerset*			*Dartington Hall*			*Both centres*		
	No. of farms	*No. of cows*	*Corrected conception rate*	*No. of farms*	*No. of cows*	*Corrected conception rate*	*No. of farms*	*No. of cows*	*Corrected conception rate*
None	17	277	66·0	4	39	57·8	21	316	65·0
Up to 3·0	28	514	64·0	9	112	55·3	37	626	62·4
3·1 – 6·0	27	460	63·4	11	89	67·5	38	549	64·1
6·1 – 9·0	17	258	62·7	8	80	60·5	25	338	62·2
9·1 – 12·0	7	140	56·9	4	40	60·2	11	180	57·6
Over 12·0	3	46	50·9	9	93	52·3	12	139	51·8
Total	99	1,695	63·0	45	453	58·6	144	2,148	62·1

RESULTS

In Table III there appeared to be a definite connection between the quantity of kale grown and the level of fertility in the winter months (October to March inclusive). Three hundred and nineteen cows in the 23 herds on farms where the kale acreage exceeded 9 per cent of the total acreage had a "corrected" conception rate of 55·1 per cent compared with 63·3 per cent for 1,829 cows in 121 herds on farms with less kale. This effect was seen independently at both centres and was magnified in herds on farms which grew kale on over

12 per cent of the total acreage. Fertility was considered only during the winter months because this is the season when kale is normally fed. However if the fertility of animals inseminated in the summer months was considered for

TABLE IV

RELATIONSHIP BETWEEN CERTAIN FARM FACTORS AND FERTILITY (SOMERSET)

Farm factor		*Number of farms*	*Number of animals*	*Corrected conception rate*
Gallons milk/cow (fertility of cows only)	Up to 1,000	20	544	61·7
	1,001 – 1,100	28	715	62·3
	1,101 – 1,200	27	785	61·5
	Over 1,200	25	601	63·5
	Total	100	2,645	62·2
Gallons milk/grass acreage (fertility of cows only)	Up to 200	15	432	58·9
	201 – 300	37	1,016	61·8
	301 – 400	30	770	65·7
	Over 400	18	427	60·4
	Total	100	2,645	62·2
"Adult" cattle/100 acres of grass	Up to 30·0	12	365	60·3
	30·1 – 40·0	20	782	59·6
	40·1 – 50·0	33	1,114	65·6
	50·1 – 60·0	22	673	62·0
	Over 60·0	13	399	61·2
	Total	100	3,333	62·4
"Total stock"/100 acres of grass	Up to 40·0	16	603	60·1
	40·1 – 50·0	21	687	64·7
	50·1 – 60·0	28	1,035	60·0
	60·1 – 70·0	20	529	68·1
	Over 70·0	15	479	60·5
	Total	100	3,333	62·4
% Temporary grass (up to 3 years)	Up to 20·0	53	1,671	62·9
	20·1 – 40·0	29	1,048	62·2
	Over 40·0	18	614	61·2
	Total	100	3,333	62·4
% Temporary grass (up to 5 years)	Up to 20	41	1,282	64·6
	21 – 40	27	964	60·0
	Over 40	32	1,087	61·8
	Total	100	3,333	62·4
% Permanent pasture (over 7 years)	0 – 20	9	256	60·2
	21 – 40	15	624	64·1
	41 – 60	17	514	58·8
	61 – 80	24	828	61·5
	81 – 100	35	1,111	64·1
	Total	100	3,333	62·4
Cows (in milk)/acre of kale (winter fertility of cows only)	Up to 3·00	21	337	61·1
	3·01 – 6·00	24	384	59·4
	6·01 – 9·00	18	369	66·7
	Over 9·00	19	328	62·5
	No kale	17	277	66·0
	Total	99	1,695	63·0
Herd founded	1954 – 56	17	517	58·7
	1950 – 53	27	925	61·9
	1941 – 49	35	1,126	63·6
	Before 1941	21	765	63·6
	Total	100	3,333	62·4

the same herds, there was no difference in fertility. In the Somerset herds all those farms that grew kale in excess of 9 per cent of the total acreage strip-grazed it to the cows. Another interesting point was the fact that winter fertility of parlour-milked herds was lower than those milked in stalls in the herds which strip-grazed kale. This difference was not seen in herds where the kale was cut and carted to the cows or in cases where no kale at all was grown. In Somerset it appeared that in herds established within three years of the survey (1954–6) fertility was poorer than in the remainder of the herds. It was noticed, however, that farms with newly established herds tended to grow more kale and were more liable to use milking parlours than farms with other herds. Statistical analysis of the material showed that the relationship between kale and poor winter fertility was significant for the Somerset material ($P<0.02$) but not for the Dartington figures.

This adverse effect of kale was also seen independently at both centres when it was assessed by the number of cows grazed per acre of kale.

The relationship between "intensity factors" and fertility is shown in Table IV. It is clear that there is no connection between fertility and either milk production per cow, milk production per acre, number of livestock per acre or the proportion of temporary grass. All these negative results were confirmed at Dartington.

DISCUSSION

The first survey, which was mentioned briefly at the beginning of this paper, demonstrated that breed differences occurred in most of the farm factors studied. That this could occur in the case of milk yield is obvious, but it also appeared to apply to the amounts of kale and temporary grass which were grown. Fertility levels and the effect on fertility of some of the farm factors, particularly milk yield and the amount of kale fed, also appeared to vary with the breed. In the second survey only one breed, British Friesian, was studied, in order to avoid these breed differences. For this reason the results which have been obtained apply only to Friesians.

There appeared to be a definite correlation between high levels of kale feeding and poor winter fertility in cows. While this applies to the Friesians in this survey, consistent results were not obtained with Guernseys and Ayrshires in the preliminary survey. Therefore it cannot be assumed on the basis of the present results that kale affects fertility and it is quite possible that kale is associated with some other factor causing infertility. There is a suggestion that the feeding of large quantities of kale was associated with a number of other factors such as the method of strip-grazing kale to cows, milking in parlours and bails as opposed to cowsheds, altitude of the farm and the date of establishment of the herd. It would therefore seem that a more thorough investigation into the part that kale plays is warranted because it may not even be a nutritional factor which is involved.

No other connection with fertility was observed with the "intensity factors" relating to milk production, rates of grazing and type of pasture grazed. It

might be argued that the use of herd measurements of "intensity" of farming is insufficiently accurate to produce reliable results and that in these circumstances negative results particularly should not be regarded as valid. However, the difference between the highest and the lowest levels of farm factors was so great (for example the milk per cow in Somerset ranged from 846 to 1,450 gallons) that it is almost certain that any important effect would have been apparent.

SUMMARY

Results from two surveys covering 145 National Milk Recorded, British Friesian herds at two artificial insemination centres in south-west England, are reported, an earlier survey of 536 herds having demonstrated the existence of breed differences in "farming intensity factors" and possibly in the fertility response to these factors. After statistical corrections for known causes of infertility had been made the winter fertility (October to March) of cows was lowered in herds where the percentage of kale grown exceeded 9 per cent of the total farm acreage. This difference was not seen for the same herds with summer conception rates. The adverse effect on winter fertility in Somerset was aggravated where kale was strip-grazed by the cows and where the cows were milked in parlours rather than stalls. To clarify the situation it is suggested that a further investigation into the possible part that kale plays in fertility is warranted. No connection was observed between fertility and the "farming intensity factors", measured by milk production per cow or acre, livestock per acre of grass and the proportion of temporary grass grown.

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CREATINE IN THE URINE OF THE DAIRY COW

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Creatinine and creatine in urine are usually estimated by the methods of Folin (1914) and Benedict (1914). Creatinine is first estimated with the rather unspecific Jaffé colour reaction (preformed creatinine) and after conversion of creatine into creatinine the same reaction is used for the so-called "total creatinine".

Because creatine is an important element of muscle creatine phosphate and not a waste product of muscle metabolism like creatinine, the excretion of creatine seems to be a peculiar loss for the organism.

In man, physiologically, creatine is found in the urine only during childhood, although it is sometimes found in the urine of adult females. High amounts of creatine are, however, found when there is a shortage of food carbohydrates; a disturbance of carbohydrate metabolism has the same effect (in diabetes and in phlorrhizin, alloxan, selenite and hydrazine poisoning). In addition, with vitamin E deficiency and a shortage of selenium, which both produce muscle dystrophy, and with muscle dystrophy and myopathy of unknown origin, a high excretion of creatine is commonly encountered.

In our and other laboratories, however, using the methods of Folin (1914) and Benedict (1914) it was found that in the urine of mature cows (and pigs) there were nearly always considerable amounts of "creatine", in contrast with what is usually found in man. So it seemed worth while to investigate with more specific methods whether it is really creatine which is excreted by these animals. (We examined only the urine of cows.)

METHODS

Whatman No. 1 filter paper was used for one-dimensional chromatography, following the methods of Anderson, Williams, Krise & Dowben (1957), with two different solvents:

(a) Pyridine—aqueous ammonia, specific gravity 0·9106 (6:3 v/v).

(b) Acetone—30 per cent acetic acid (6:4 v/v).

After being dried at room temperature the papers were heated for three hours at 110°C in an oven, to convert creatine into creatinine (Maw, 1948), and were then sprayed with a mixture of 1·2 per cent picric acid in methanol and 6 per cent sodium hydroxide in methanol (3:1 v/v). Creatinine gives an orange spot on a yellow background with this Jaffé reaction.

The *creatinine* content of the urine was estimated in three different ways:

(1) With the micromethod of Folin (1914), slightly modified: a volume of urine containing 0·5–1 mg. creatinine (0·5–2 ml.) is diluted to a volume of 5 ml. with distilled water in a volumetric flask of 100 ml. Then 3 ml. of a saturated picric acid solution in water and 2 ml. 10 per cent sodium hydroxide are added.* After ten minutes the flask is filled to the 100 ml. mark and again after 20 minutes the colour is measured in a colorimeter against water as the control, using filter 53.

(2) With the method of van Pilsum, Martin, Kito & Hess (1956), who converted the creatinine into methylguanidine by oxidation with *o*-nitrobenzaldehyde. Methylguanidine gives with *α*-naphthol thymine and sodium hypochlorite the Sakaguchi colour reaction which is specific for guanidine compounds. The only other substances in urine which give a positive Sakaguchi reaction are probably arginine and guanidine acetic acid (glycocyamine).

(3) With the method of De Vries and Van Daatselaar (*see* Gorter & de Graaf, 1955), who carried out the Jaffé colour reaction after adsorption on fullers' earth (Frankonite K.L.) and elution with 0·05 M–$MgCl_2$.

The *creatine* plus *creatinine* concentration was estimated:

(1) After conversion of the creatine into creatinine following the method of Benedict (1914): a volume of urine containing 0·5–1 mg. total creatinine (0·25–1 ml.) mixed with 4 ml. 1 N-HCl and a little granulated lead (about 25 mg.) is evaporated to dryness in a water-bath. The residue is dissolved in 1·5 ml. of water by heating for five minutes in the water-bath (covered with a watch-glass). After cooling this solution is filtered through a small plug of cotton wool in a 100 ml. volumetric flask and washed three times with 1·2 ml. of distilled water. On the filtrate the same colour reaction is carried out as described for creatinine (Folin, 1914).

(2) Creatine was converted into creatinine as described under (1) and then the total amount of creatinine estimated by the method of van Pilsum *et al.* (1956).

(3) Creatine was converted into creatinine as described under (1), then the total creatinine was estimated using the method of De Vries and Van Daatselaar (*see* Gorter & de Graaf, 1955).

All the creatine values are expressed as mg./100 ml. creatinine; to get the real creatine content one has to multiply these values by 1·16.

RESULTS

A. Chromatography

The chromatograms of the urine of normal cows commonly showed two distinct spots, with R_F values corresponding with those of solutions of pure creatinine

*It was found, however, after finishing this investigation, that the original method of Folin with 20 ml. of saturated picric acid and 1·5 ml. of NaOH gives a more stable colour and is less influenced by ketone bodies.

and creatine in water (Fig. 1). If the chromatograms were sprayed without conversion of creatine into creatinine by heat, only one spot developed, corresponding with that of creatinine. The two different solvents gave identical results.

B. Quantitative estimations in urine with different methods

In five samples originating from five housed cows the creatinine content was estimated on three successive days by the method of Folin (1914). The same urine samples were used, after being diluted to 1:500, for the creatinine estimation (van Pilsum *et al.*, 1956). The results are summarized in Table I.

The creatine plus creatinine content was estimated by the methods of Benedict (1914) and of van Pilsum *et al.* (1956) in a dilution of 1:500 (*see* under Methods).

To check whether these estimation methods were influenced by the diet, urine samples of five cows at pasture were examined in the same way. Because the concentration of this urine was rather low, urine dilutions of 1:250 for creatinine and of 1:250 and 1:500 for creatine plus creatinine estimations were used for the method of van Pilsum *et al.* (Table II).

In Tables III and IV the results of the estimations made by the method of De Vries and Van Daatselaar (*see* Gorter & de Graaf, 1955) are summarized. The urines of five cows on pasture and six different urine samples of a cow in the stable, diluted to 1:100, were examined. In the same samples creatinine and creatinine plus creatine were estimated with the methods of Folin (1914) and Benedict (1914).

From the figures of the Tables I–IV the conclusion can be drawn that the

TABLE I

COMPARISON OF DIFFERENT CREATININE AND CREATINE PLUS CREATININE ESTIMATION METHODS IN URINE OF COWS IN THE STABLE

			Creatinine (mg./100 ml.)				*Creatine plus creatinine (mg./100ml.)*		
			Folin			*van Pilsum et al.*	*Benedict*		*van Pilsum et al.*
Cow no.	*Description*	*Daily ration*	20/9	21/9	22/9	20/9	22/9	23/9	23/9
I	650 kg. live weight 12 kg. milk/day pregnant (5 months)	12 kg. hay 4 kg. cake water *ad lib.*	64	63	62	65	98	95	100
II	600 kg. live weight dry non-pregnant	6 kg. hay water *ad lib.*	174	170	168	175	180	178	175
III	608 kg. live weight dry non-pregnant	7½ kg. hay water *ad lib.*	152	148	152	152·5	182	177	185
IV	600 kg. live weight dry non-pregnant	7½ kg. hay water *ad lib.*	194	192	194	194	262	262	265
V*	530 kg. live weight dry non-pregnant	6 kg. hay water *ad lib.*	100	96	92	107·5	132	110	120

* The urine sample of this cow contained some faeces.

methods of Folin and Benedict give fairly reliable results (*see* under Discussion); they were therefore used for the estimation of the creatinine and creatine plus creatinine content of the urine of quite a number of cows, on pasture as well as in the stable. With the values obtained we calculated the ratio

$$\frac{\text{creatine (mg./100 ml.)}}{\text{creatinine (mg./100 ml.)}} \text{(C.C.R.)}$$

which is a convenient index for the quantity of creatine excreted, because when the diet is not changed, the excretion of creatinine and also of creatine is constant during the day (de Groot and Aafjes, 1960). The results are summarized in Tables V–IX and Figs. 2–5.

TABLE II

COMPARISON OF DIFFERENT CREATININE AND CREATINE PLUS CREATININE ESTIMATION METHODS IN URINE OF COWS ON PASTURE

Cow no.	*Milk production kg./day*	*creatinine (mg./100 ml.)*				*creatine plus creatinine (mg./100 ml.)*						
		Folin		*van Pilsum et al.*		*Benedict*		*van Pilsum et. al.*				
								dilution 1:250		*dilution 1:500*		
VI	13	34	34	32·5	32	72	72	66·5	67	69	64	67
VII	14	46	46	46	46	87	86	80	80	74	79	74
VIII	10	45·5	45·5	48·5	48·5	90	87	82·5	82	85	83	78
IX	10	40·5	40·5	43·5	43·5	98	98	96·5	92·5	95	96	87·5
X	12	41	41	42	42	104	102	98·5	—	97	91	94

TABLE III

COMPARISON OF DIFFERENT CREATININE AND CREATINE PLUS CREATININE ESTIMATION METHODS IN URINE OF COWS ON PASTURE

Cow no.	*Milk production kg./day*	*creatinine (mg./100 ml.)*		*creatine plus creatinine (mg./100 ml.)*	
		Folin	*De Vries and Van Daatselaar*	*Benedict*	*De Vries and Van Daatselaar*
VIII	13	51	51·5	94	86
X	24	49	48	78	71·5
XI	11	28	26	54	47·5
XII	20	51	—	115	110
XIII	19	43	44	66	61

C. Quantitative estimation in urine with the methods of Folin and of Benedict

Table V concerns an experiment made accidently by a farmer who changed the rations of his herd of some 40 milking cows four times during the early spring months of 1960, with the intention of producing more milk at lower cost. Until February 27 the rations contained a shortage of energy of about 1·5 units of starch equivalent for the cows with the highest milk production. From February 27 beet pulp and maize meal were given in addition, sufficient to fill this gap. However, because this made feeding more expensive and caused a drop in the fat percentage of the milk, the supplementation was stopped on March 10, making the ration again insufficient until March 25, when potato pulp was added to the concentrates already fed.

From the milk production per "standard cow" (Doeksen & Heyboer, 1952)

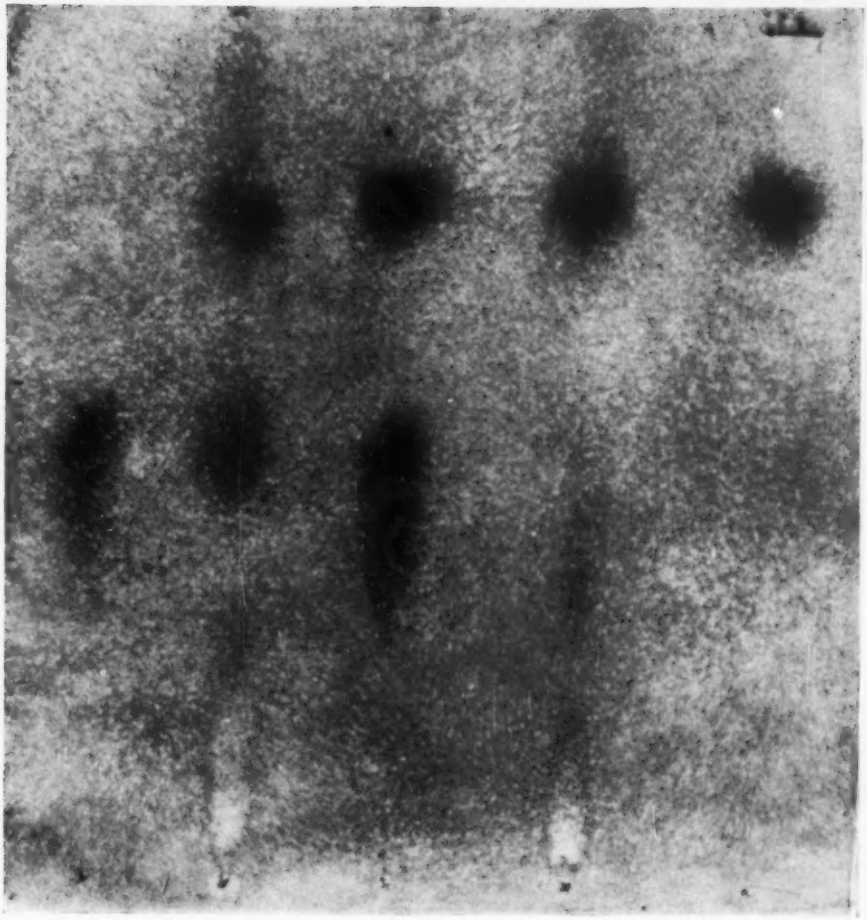

Fig. 1. Chromatogram of:

(1). Ten µl. of a solution containing 116 mg. of creatine/100 ml. (equivalent to a solution of 100 mg. creatinine/100 ml.)

(2). Fifteen µl. of the urine of cow X as used for Table II.

(3). Ten µl. of the same solution as (1) plus 10 µl. of the same solution as (5).

(4). Six µl. of the same solution from cow II as used for Table I.

(5). Ten µl. of a solution containing 100 mg. of creatinine/100 ml.

TABLE IV

COMPARISON OF DIFFERENT CREATININE AND CREATINE PLUS CREATININE ESTIMATION METHODS IN THE URINE OF A COW IN THE STABLE

Cow no.	*Milk production*	*(creatinine mg./100 ml.)*		*creatine plus creatinine (mg./100 ml.)*	
		Folin	*De Vries and Van Daatselaar*	*Benedict*	*De Vries and Van Daatselaar*
XIV	dry	157	160	180	184
		146	150	164	170
		166	162	186	190
		130	136	152	154
		152	156	179	180
		146	146	157	160

and the average fat percentage of the milk of this herd a graph was constructed (Fig. 2). The influence of the different rations seems quite evident and strengthens the idea that the diet was insufficient before February 27 and March 10 until March 25 (low milk production, high fat percentage). During the period from February 27 until March 10 and again after March 25 when more starch equivalents were fed, the milk production increased and the fat percentage decreased (Table VI).

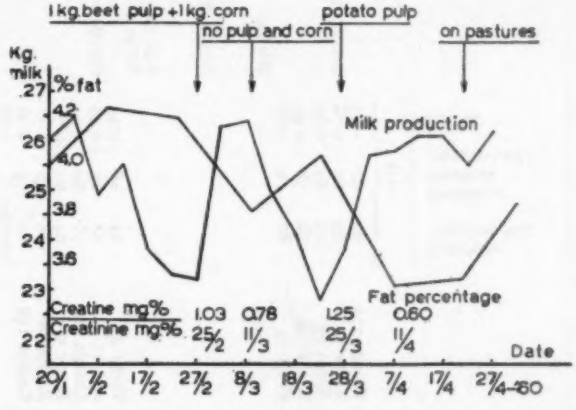

Fig. 2. Variations caused by changes in the diet in the milk production per "standard cow" and in the fat percentage, on a practice farm.

Probably because of the changes in the diet a profound influence on the creatine excretion was exerted; with more starch equivalents in the ration, the C.C.R. in the urine goes down and rises again when the ration becomes insufficient in energy (the differences between the quotients on the different dates are statistically significant using Wilcoxon's test: $0{\cdot}05 > P > 0{\cdot}01$).

About the same picture is seen in Table VII and Fig. 3 which are composed of figures obtained from a herd of the Institute for Biological and Chemical Research on Field Crops and Herbage at Wageningen. From the cows of this herd urine was collected on four different dates during the time the animals

TABLE V

C.C.R. IN THE URINE OF COWS ON DIFFERENT DATES FOLLOWING CHANGES IN FEEDING

Date:	Creatinine (mg./100 ml.)	Creatine as creatinine (mg./100 ml.)	C.C.R.
	25/2		
Catrijn 131	50	58	1·16
Eertje 50	56	60	1·07
Eertje 33	66	68	1·03
Rinkje 66	65	85	1·31
Pietje 63	81	47	0·58
Hielkje	51	79	1·55
Trijntje 29	78	71	0·90
Catrijn 139	66	64	0·97
Eertje 46	51	47	0·92
Rinkje 64	88	80	0·91
Eertje 39	68	68	1·00
Atje 12	43	53	1·23
Rinkje 61	63	57	0·90
Eertje 25	56	50	0·90
Willy 24	81	81	1·00
Rinkje 63	55	53	0·96
Average			1·03

	Creatinine (mg./100 ml.)	Creatine as creatinine (mg./100 ml.)	C.C.R.
	11/3		
Catrijn 131	69	71	1·03
Eertje 50	89	69	0·78
Eertje 33	109	89	0·82
Rinkje 66	82	78	0·95
Pietje 63	82	72	0·88
Eertje 47	64	28	0·44
Atje 11	54	23	0·43
Catrijn 129	76	80	1·05
Eertje 36	84	60	0·71
Rinkje 78	115	59	0·51
Catrijn 148	81	79	0·98
Average			0·78

	Creatinine (mg./100 ml.)	Creatine as creatinine (mg./100 ml.)	C.C.R.
	25/3		
Eertje 50	45	45	1·00
Hielkje	42	62	1·48
Eertje 46	47	55	1·17
Atje 12	48	52	1·08
Eertje 41	22	36	1·64
Catrijn 109	56	64	1·14
Average			1·25

	Creatinine (mg./100 ml.)	Creatine as creatinine (mg./100 ml.)	C.C.R.
	11/4		
Eertje 33	59	29	0·49
Pietje 63	52	26	0·50
Hielkje	65	31	0·48
Trijntje 29	54	30	0·56
Catrijn 139	59	29	0·49
Eertje 46	55	39	0·71
Rinkje 64	69	51	0·74
Eertje 39	44	26	0·59
Eertje 41	64	56	0·875
Eertje 47	37	21	0·57
Average			0·61

(Some of the urine samples contained ketone bodies, which will have increased the value obtained for the creatine).

TABLE VI

C.C.R., MILK PRODUCTION AND FAT PERCENTAGE AT DIFFERENT FEEDING LEVELS ON A PRACTICE FARM

Date of collection of urine	*Diet during preceding ten days*	*C.C.R.*	*Total milk production of herd (kg.)*	*Average fat %*	*Date of milk control*	*No. of cows*
25/2	Insufficient	1·03	568·4	4·19	23/2	35
11/3	Sufficient	0·78	691·2	3·82	9/3	40
25/3	Insufficient	1·25	632·2	4·04	23/3	41
11/4	Sufficient	0·60	726·6	3·51	7/4	41

were changed from the barn to the pasture and back again, respectively on April 14 and October 28, 1960. Out of the creatine and creatinine concentrations in these urine samples, the C.C.R. was computed (Table VII). When the results from cows 1–8 are analysed (of these cows a urine sample was collected on all four dates) the average values of these quotients were:

14.4.1960 : 0·68
26.4.1960 : 0·57
26.10.1960 : 1·23
5.11.1960 : 0·77

The differences between these averages are statistically significant ($P=0{\cdot}02$).

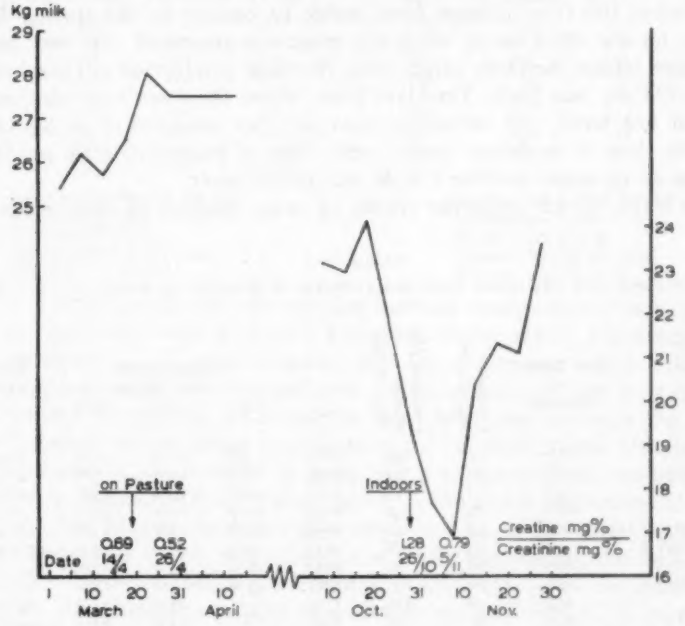

Fig. 3. Milk production per "standard cow" on an experimental farm before and after transition from stable to pasture and back again.

TABLE VII

C.C.R. IN THE URINE OF COWS ON DIFFERENT DATES ON AN EXPERIMENTAL FARM AFTER CHANGE IN FEEDING

No.	Cow	Date of calving	14–4–60 barn	26–4–60 pasture	26–10–60 pasture	5–11–60 barn
1.	Ymkje 10	14–2–60	0·60	0·57	1·32	0·66
2.	Renske 14AEV	13–1–60	0·52	0·52	1·22	0·61
3.	Benedictus	2–3–60	0·64	0·47	0·79	0·70
4.	Gees A 8	24–11–59	0·66	0·61	1·82	0·80
5.	Kl. Anke	2–1–60	0·63	0·58	0·94	0·90
6.	Janke 117 AEV	14–2–60	0·88	0·59	1·33	0·88
7.	Hylkje 4	7–4–60	0·84	0·64	1·76	0·85
8.	Renske 13	21–10–59	0·71	0·57	0·66	0·75
9.	Janke 115	2–3–60	0·58	0·77		
10.	Ureterp Joh. 17	14–2–60	0·39	0·13	1·25	
11.	Dientje J. M.	16–1–60		0·29	1·21	0·37
12.	Janke 113	16–3–60	1·15	0·85		
13.	Sjoerdje 17 FS	1–12–59	0·55	0·21	1·14	
14.	Janna 3	18–2–60	0·81		1·62	1·34
	Mean		0·69	0·52	1·26	0·79

During the time these urine samples were taken for estimation of the creatine and creatinine content, the milk production per "standard cow" (Doeksen & Heyboer, 1952) of the herd was calculated (Fig. 3). Here it is again seen that a higher milk production is accompanied by a lower creatine output when the cows change from stable to pasture in the spring. In the autumn, on the other hand, when the grass was poor and very wet and the dry matter intake therefore rather low, the milk production declined steeply and the C.C.R. was high. Ten days later, when the cows had been indoors for about one week (the ration per cow per day consisted of 40 kg. of beet tops, 6 kg. hay of moderate quality and 2 kg. of peastraw) milk production started to go up again and the C.C.R. was much lower.

Table VIII, which gives the results of urine analysis of cows on pasture

TABLE VIII

CREATININE AND CREATINE PLUS CREATININE EXCRETION OF COWS ON PASTURE

Cow	Date (1960) of estimation	Creatinine (mg./100 ml.)	Creatinine plus creatine (mg./100 ml.)	C.C.R.	Milk production in kg./day on: 12/5	1/6	23/6	Date of calving
Jansje 2	1/6	51	94	0·84	13·6	12·8	10·0	6–4–1960
Witschoft 5	1/6	28	54	0·93	11·6	10·6	7·6	4–5–1959
Eke 42	2/6	51	115	1·25	24·6	19·2	14·6	2–3–1960
Eke 42	16/6	70	136	0·94	24·6	19·2	14·6	2–3–1960
Lamkje 6	2/6	49	78	0·59	25·8	23·8	17·6	19–3–1960
Zwartschoft 5	2/6	43	66	0·53	19·2	19·0	15·0	25–10–1959
Lamkje 7	9/6	60	88	0·47	16·0	14·4	12·0	30–3–1960
Lionne 14	9/6	60	100	0·67	15·6	14·6	13·2	24–3–1960
Roosje	9/6	58	122	1·10	—	24·2	24·2	24–5–1960
Roosje	16/6	50	98	0·96	—	24·2	24·2	24–5–1960
Annie 7	13/6	49	119	1·93	—	—	23·8	2–6–1960
Annie 7	16/6	58	140	1·41	—	—	23·8	2–6–1960
Witschoft 14	16/6	75	140	0·87	28·6	25·2	19·0	23–3–1960

together with milk production and date of calving, shows that the C.C.R. is of the same order as for cows in the stable, a higher excretion of creatine being encountered shortly after calving, especially (*see* also Fig. 5, where the dotted line shows the increase of the C.C.R. of a cow, Betsy, which calved on October 9).

The cow Eke 42 does not fit in with this, but it is seen that her milk production is declining rather sharply, which is the same situation as encountered in Fig. 2, where a high creatine excretion is accompanied by a drop in the milk production. Nevertheless when there is no milk production at all, there is commonly a very low excretion of creatine.

Table IX gives the results of creatine and creatine plus creatinine estimations in the urine of two dry cows used for an energy-balance experiment. Some data of the preliminary energy balance and the C.C.R. are included in this table. Here again it is seen that although the creatine output is very low, the smaller amount of available energy occurs with a higher C.C.R.

TABLE IX

CREATININE AND CREATININE PLUS CREATINE EXCRETION OF TWO COWS, USED FOR A BALANCE EXPERIMENT

Cow 3: 6½ kg. of hay, mown at an early stage

Date (1960)	*Creatinine* (mg./100 ml.)	*Creatinine plus creatine* (mg./100 ml.)	*C.C.R.*
10/6	99	110	0·11
11/6	120	146	0·22
14/6	96	117	0·22
15/6	99	114	0·15
16/6	105	124	0·18
17/6	98	110	0·12
18/6	91	104	0·14
19/6	103	128	0·22
20/6	90	106	0·18

Cow 3: live weight 560 kg.
Preliminary data:
intake kcal. 24·800
Digestibility 69 per cent
Balance −100 kcal.

Cow 4: 9½ kg. of hay, mown at a more mature stage

Date (1960)	*Creatinine* (mg./100 ml.)	*Creatinine plus creatine* (mg./100 ml.)	*C.C.R.*
10/6	137	138	0·01
14/6	113	112	—
15/6	108	107	—
16/6	70	72	0·03
17/6	115	106	—
18/6	111	114	0·03
19/6	106	112	0·06
20/6	101	102	0·01

Cow 4: live weight 580 kg.
Preliminary data:
intake kcal. 35·500
Digestibility 55 per cent
Balance +1,000 kcal.

To get a better insight into the relation between energy intake and creatine output an experiment was done with a dry cow in the stable. The experiment started on April 6, 1960 with a ration of 7 kg. of hay and water *ad libitum*. On April 19 the ration was changed into 3·5 kg. of hay and 800 g. of concentrates, keeping the protein intake at the same level and lowering the intake of starch equivalents to about two-thirds of the original ration. On April 29 the amount of hay was lowered to 2 kg. and the concentrates were brought up to 1,000 g. This caused an overall deficit of the starch equivalent of about 50 per cent. On May 6, the cow again received 7 kg. of hay without concentrates. In the urine, which was collected several times during the day in the same way as described earlier (de Groot & Aafjes, 1960), the creatinine and the creatine plus creatinine content were determined and the C.C.R. computed (Fig. 4). No urine was collected from May 11 to May 18 because a sore developed under the harness.

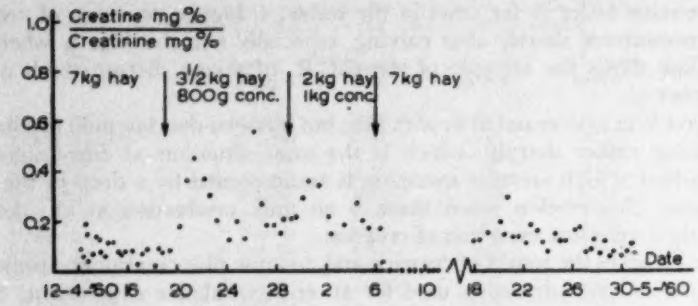

Fig. 4. C.C.R. in the urine of a cow on different rations.

The graph shows not only that lowering of the energy intake causes a higher C.C.R. but also that this ratio declines steeply when adequate feeding is resumed after a time of shortage of food. In one day, after the same ration was given as at the start of the experiment, the creatine excretion even decreased to zero and remained so for several days.

These results support the following conclusions of Boyd Orr (1918):

"1. In ruminants creatine is normally excreted in relatively large quantities.

"2. The amount of creatine excreted is in inverse proportion to the amount of carbohydrate in the diet.

"3. Cessation of lactation causes a decrease in the amount of creatine excreted".

DISCUSSION

On the chromatograms of the urine samples the only spot with a positive Jaffé reaction was creatinine, judged by its R_F value. After the samples were heated a second spot developed with a positive Jaffé reaction with an R_F value corresponding with that of creatine. It is known, however, that by heating glycocyamine glycocyamidine is formed, a substance which also gives a positive Jaffé reaction (Hunter, 1928). As the R_F value of glycocyamine is practically the same as that for creatine (Anderson *et al.*, 1957) the possibility existed that a part of this second spot was formed by glycocyamine (if this should be the case at least a part of what was estimated as creatine by the method of Benedict (1914) might be glycocyamine instead of creatine). That this could be only a minor part was shown by the chromatography of a pure solution of glycocyamine containing 200 mg. per 100 ml. (almost half saturated), which gave only a very faint orange spot. The chromatography thus leads to the conclusion that in the urine of cows there is often an important amount of creatine. Besides this, there were probably no other substances giving Jaffé-positive compounds after heating unless these substances had the same R_F value as either creatine or creatinine in an acid as well as in an alkaline solvent system.

It is known that the Sakaguchi reaction and the absorption method of

De Vries and Van Daatselaar are much more specific than the Jaffé reaction in the estimation of creatinine (van Pilsum, 1959). This implies that when other Jaffé-positive substances are formed during the conversion of creatine into creatinine, they probably will not be estimated with these more specific methods. In this case the sum of creatine and creatinine would be lower when it was estimated with these methods than with the method of Benedict (1914).

Van Pilsum *et al.* (1956) mention that their creatinine estimations (probably in human urine) with the method of Folin (1914) and their own method were "for all practical purposes identical". We found the same for the urine of cows (Tables I and II) and this proves that there cannot be a high amount of glycocyamine in these urine samples because glycocyamine gives a positive reaction with the Sakaguchi reagents. If much glycocyamine had been present in the urine of cows this would have resulted in a higher creatinine content with the method of van Pilsum *et al.* (1956) than with Folin's (1914) method.

The same agreement was found between the creatinine estimations with the method of De Vries and Van Daatselaar (*see* Gorter & de Graaf, 1955) and that of Folin (Tables III and IV). Indeed the figures of the concentrated urine of cow XIV (Table IV) show that both the creatinine and the creatinine plus creatine estimations of Benedict are a little lower than the estimations in the same urine with the methods of De Vries and Van Daatselaar, but this is probably caused by other substances (as described by van Pilsum *et al.* for the Sakaguchi reaction) which disturbed the Jaffé reaction. Dilution of a concentrated urine resulted in a higher creatinine figure. For instance, a urine sample which contained 160 mg. creatinine per 100 ml. according to the method of van Pilsum *et al.* (1956) gave with the method of Folin the following results:

with 0·25 ml. an estimation of 164 mg. creatinine/100 ml.
with 0·75 ml. an estimation of 158 mg. creatinine/100 ml.
with 1·00 ml. an estimation of 151 mg. creatinine/100 ml.

This shows that it is absolutely necessary to take a urine dilution with a concentration between 50 and 100 mg. per 100 ml. for the estimations with the methods of Folin and of Benedict. When this is done, a standard deviation of 1·7 for a single creatinine estimation, following Folin's method, was found (the urine of cow V excluded).

For the estimation of creatine plus creatinine in the urine of cows in the stable a good agreement was found between the methods of van Pilsum *et al.* (1956) and of De Vries and Van Daatselaar on the one hand, and the method of Benedict on the other (Tables I and IV). For cows on pasture the method of Benedict gave slightly higher values than the other two methods. This difference was statistically significant ($0{\cdot}05 > P > 0{\cdot}01$) and may be caused by a substance or substances in the urine of cows on pasture which give a Jaffé-positive compound with the method of Benedict and which is not creatinine. For the single creatine plus creatinine estimation with Benedict's method a standard deviation of 1·7 was again calculated (the urine of cow V excluded).

The results of the creatine and creatinine determinations in the urine of

cows under different conditions led to the same conclusions about the creatine excretion as were drawn by Orr (1918). It is important to emphasize that these results were obtained by calculating the C.C.R. of *single samples* and not by collecting all the urine excreted per day and computing the total amount of creatine as was done by Orr.

For practical purposes our method of analysing only one sample of urine of each of a number of cows in a herd seems useful to determine whether the herd shows a high creatine excretion or not and especially whether the C.C.R. declines after about a week when a ration with a higher starch equivalent content is fed. If this is the case, the first ration had an energy value which was too low.

When the publication of Orr is read again now, when much more is known about creatine metabolism, one is struck by the views he already had in 1918. He says, for example: "It may be that creatine, or whatever body represents it in the tissues, serves as a connecting link securing the incorporation of the carbohydrate molecule within the protoplasm complex".

Our present knowledge of creatine metabolism is more or less as follows: glycocyamine, which is produced in the kidney out of arginine and glycine by transdeamination (Borsook & Dubnoff, 1941), is transformed in the liver into creatine by methylation with activated methionine (Cantoni & Vignos, 1954). After transport by the blood stream, creatine is used in the muscles in the form of creatine phosphate as an energy accumulator, a donor of active phosphate groups for muscular activity. Normally a certain amount of this creatine phosphate store in the muscles is hydrolysed with a constant speed and gives rise to an amount of creatinine which is of no further use to the body and is therefore excreted with the urine (Borsook & Dubnoff, 1947). Because this hydrolysis of creatine phosphate seems to be a physico-chemical (and not an enzymic) process with a constant rate, this may be the cause of the constant excretion of creatinine by the animal.

Through this mechanism about 2 per cent of the stock of creatine phosphate in the body is lost every day. This must be replenished by new formation in the muscle from creatine (produced in the liver) and adenosine triphosphate (ATP) which is generated by degradation of glucose, for example.

In the muscle cell creatine phosphate produces active phosphate groups when contraction is performed, by the following reversible reaction:

$$\text{creatine phosphate} + \text{ADP} \rightleftharpoons \text{ATP} + \text{creatine}$$

Creatine phosphate is reconstituted when the supply of ATP exceeds the need for muscle contraction.

The fact that normally a relatively large quantity of creatine is excreted by cows must mean that the production in the liver exceeds the requirements of the muscles for the replenishment of creatine phosphate which is lost as creatinine. This same situation is encountered in muscular dystrophy, where the demand from the degenerated muscle is so low that the excess creatine produced by the liver is excreted as such (Benedict, Kalinsky, Scarrone, Wertheim & Stetten, 1955).

When there is a shortage of food it seems improbable that more creatine is

produced in the liver (for which energy is needed); so the explanation for the higher excretion of creatine in this situation must be a lowered uptake by the muscles, which may be caused by a shortage of glucose.

The other explanation, that the amount of creatine excreted is derived from muscle creatine phosphate, is improbable, because muscle function is not disturbed and the creatine concentration of the muscles is not lowered by starvation, a fact already known to Orr (1918).

Nevertheless it is conceivable that an overall shortage of creatine exists, which must be made good when an adequate ration is resumed after a period of starvation. Indeed this is seen in Fig. 4, where the cow excreted no creatine at all when the original diet of 7 kg. of hay was given again, and the C.C.R. returned to the same level as it had at the start of the experiment only after some time.

The explanation of the observed facts seems to be as follows. Through the large amount of feed eaten by highly productive cows, a certain quantity of creatine is formed in the liver, in excess of the need of the muscles, and this is excreted in the urine. It is possible that certain kinds of feed give rise to a higher creatine production. (We sometimes had the impression that this was the case with silage and perhaps also with grass, but this is not quite certain because we used Benedict's method for the estimation of creatine and this method, as has been shown, is not quite reliable when grass is fed.)

When there is a shortage of carbohydrates the excretion of creatine becomes still higher because the uptake of creatine in the muscles is disturbed. The most important consequence of this high creatine excretion, however, is that it makes it possible to detect a very important decrease of the C.C.R., when more feed is given, because a large part of the surplus of creatine will then be used to replenish the muscle stores. A consequence of this theory is that when the carbohydrate supply is not insufficient, feeding more energy will not result in an important drop in the C.C.R., which in this case is not abnormally high.

This seems to be proved by an experiment with 16 cows, of which nine received 1·5 kg. of concentrates daily, in excess of their already sufficient ration. The C.C.R. did not show a statistically significant difference between the experimental group and the control group after about four days. The difference on the 9th and 10th November is significant when Wilcoxon's test is used ($0{\cdot}05>P>0{\cdot}01$). In Fig. 5 the results of this experiment are plotted graphically. We are not able to explain the slight increase in the C.C.R. that both groups seem to show.

With this theory the high excretion of creatine at the start of lactation can also be explained (Cow Betsy: Fig. 5 and Table VIII). In the first place at that time the liver produces much creatine (more than normally, in connection with the demand of the pregnant uterus) which after parturition is no longer necessary. In the second place the requirement of carbohydrates rises suddenly when the milk flow starts. In the third place there is possibly some creatine released by the involution of the uterus.

It is realized that in the foregoing "a shortage of feed" was used as meaning

"a shortage of carbohydrates"—evidently there is no other possibility; on the other hand, however, it is highly probable that, especially in ruminants, there can be a situation in which there is sufficient feed (starch equivalents), but nevertheless a shortage of carbohydrates. It may be that the estimation of the creatine output also reveals this last situation.

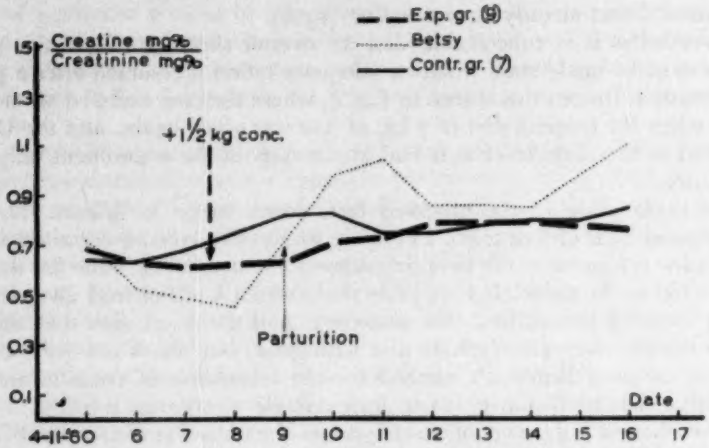

Fig. 5. C.C.R. of two groups of cows of which one group received extra concentrates, and of a single cow (Betsy) which calved during the experimental period.

SUMMARY

In the urine of cows creatine is found in substantial amounts. This is proved chromatographically as well as with the more specific methods of estimation of van Pilsum, Martin, Kito & Hess (1956) and of De Vries & Van Daatselaar (*see* Gorter & de Graaf, 1955).

The amount of creatine excreted can vary considerably. The causes of this variation are discussed.

Folin's (1914) method of creatinine determination, if carried out in the right dilution (the concentration of creatinine being between 50 and 100 mg. per 100 ml.), is reliable.

The same can be said of the creatine determination according to Benedict (1914) in the urine of cows in the stable. In the urine of cows on pasture the creatine content estimated with this method is a little bit too high.

The quotient $\frac{\text{creatine (mg./100 ml.)}}{\text{creatinine (mg./100 ml.)}}$ (C.C.R.) seems to be an important index of the adequacy of carbohydrates in the diet and it can probably be used to check this in practice.

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THE EFFECT OF ENVIRONMENTAL TEMPERATURE ON THE GROWTH RESPONSE OF CHICKS TO AN ANTIBIOTIC SUPPLEMENT IN THE DIET

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Ever since the artificial rearing of chicks began it has been realized that, particularly for the first three or four weeks of life, chicks have to be kept at a high temperature. Pritchett (1940) observed that healthy chicks were quiet and apparently comfortable all over the hover area whenever temperatures recorded at a height of 2·5 inches above the litter were within a range of 80° to 110°F. Not until temperatures as low as 75° or as high as 125°F were reached were areas definitely avoided by the chicks.

It has also been clearly established that low concentrations of antibiotics in the food will improve the growth rate of apparently healthy chicks, this growth-promoting effect being most marked while the chicks are young. In general the best results are obtained on farms which are hygienically poor, and antibiotics improve the response to poor quality rations to a greater extent than that to well-balanced diets. However there are undoubtedly other factors which can influence the response of chicks to antibiotic feeding, and further studies are needed to determine what these are.

One of these factors may be the environmental temperature, as it has been found with pigs (King, 1960) that the supplementation of the diet with oxytetracycline hydrochloride has a greater effect on weight gain and the efficiency of food utilization in pigs kept at an environmental temperature of about 54°F than in pigs kept at about 65°F. In an attempt to determine whether the growth response of chicks to an antibiotic was influenced in a similar manner by the environmental temperature, the experiments reported here were designed to investigate the effects of two environmental temperatures, both within the usually accepted range of normality, on the rate of weight gain of chicks during the first three weeks of life; these chicks were fed on a basic diet or on this basic diet supplemented with penicillin.

EXPERIMENTAL METHOD

Chicks

Four hundred and forty-four chicks were used in eleven batches. In each batch the chicks were divided into four groups, as even in weight as possible (Table I). One hundred and twenty-eight of the chicks were Leghorn pullets, and the remaining 316 were Rhode Island Red × Light Sussex cockerels.

At a day old the chicks were wing-banded and weighed, and each chick was subsequently weighed weekly. As only six chicks died in all, and their weights have not been included in the results, the mortality rate per ration has not been shown.

Housing

The chicks were accommodated in two similar electrically heated single-tier battery brooders. Each brooder was divided down the centre by a partition; the chicks in one compartment were fed on the control diet and those in the other on the supplemented diet. The chicks were kept in the enclosed section of the brooder for the first two weeks, but were allowed access to a small additional unheated area during the third week of life. One brooder was maintained at a "warm" temperature of about 95°F for the first week, 90°F for the second week and 85°F for the third, and the other at a "cool" temperature of about 85°F for the first week, 80°F for the second and 75°F for the third. The hover temperatures were taken twice daily at 8.30 a.m. and 4.30 p.m.

TABLE I

THE AVERAGE LIVE-WEIGHT GAINS (G.) OF A TOTAL OF 444 CHICKS KEPT IN 11 BATCHES FOR 3 WEEKS AT 2 ENVIRONMENTAL TEMPERATURE LEVELS AND FED ON 2 DIETS, A BASIC RATION (N) AND THIS RATION SUPPLEMENTED WITH PENICILLIN (A)

Batch No.	*Total no. of chicks*	*Breed*	*Warm hover*			*Cool hover*		
			A	*N*	*A-N*	*A*	*N*	*A-N*
1	32	Leghorn	191	196	− 5	180	160	+20
2	32	Leghorn	138	159	−21	143	151	− 8
3	48	R.I.R. × L.S.	218	197	+21	202	182	+20
4	52	R.I.R. × L.S.	196	172	+24	197	176	+21
5	52	R.I.R. × L.S.	201	189	+12	184	180	+ 4
6	44	R.I.R. × L.S.	202	225	−23	211	206	+ 5
7	32	Leghorn	181	187	− 6	173	176	− 3
8	32	Leghorn	177	175	+ 2	187	172	+15
9	40	R.I.R. × L.S.	194	198	− 4	194	196	− 2
10	40	R.I.R. × L.S.	239	181	+58	187	177	+10
11	40	R.I.R. × L.S.	199	184	+15	211	186	+25

TABLE II

SUMMARY OF THE DATA CONTAINED IN TABLE I

Diet	*Warm hover (W)*		*Cool hover (C)*		*Difference W-C*
	Average weight gain (g.)	*Diff. A-N*	*Average weight gain (g.)*	*Diff. A-N*	
A	194·1	6·6†	188·1	9·7*	6·0†
N	187·5		178·4		9·1*

* significant at the 5 per cent level of significance
† not significant.

Feeding

The basic diet throughout consisted of a proprietary chick mash with the following percentage analysis—protein 18·5, fat 3·0 and fibre 4·5. It was fed unsupplemented or with the addition of penicillin at the rate of 55 g. of procaine

penicillin per ton of food (added in the form of Vitablend Penicillin Concentrate, Glaxo Ltd.). The meal was fed dry *ad libitum*, free access to water being allowed.

RESULTS

Although the thermostats were set at the temperatures previously given, the actual temperatures attained varied slightly, and were 93·5° for the first week, 91·4° for the second and 86·3°F for the third week in the "warm" brooder, 82·7° for the first week, 80·7° for the second and 77·1°F for the third in the "cool" brooder.

The average live-weight gains of the chicks are given in Table I.

DISCUSSION

The effects of environmental temperature differences

In nine of the 11 batches the chicks on the basic diet grew more rapidly in the warm environment than in the cool, and in the other two experiments the differences between the figures for the two temperature levels were small. The difference between the average live-weight increases of the chicks was significant at the 5 per cent level of significance. Of the chicks receiving the supplemented diet in five experiments those in the warm environment grew more rapidly, in five those in the cool environment gained the most weight, and in the remaining experiment there was no difference. There was no significant difference between the live-weight increases of the chicks kept at the two environmental temperature levels.

The effects of the antibiotic supplement

In six of the 11 experiments with chicks kept in the warm hover those fed on the supplemented diet gained more weight than those on the basic diet, while in eight batches kept in the cool hover those receiving the antibiotic gained more rapidly than the controls, and in the remaining three the differences between the weights of the birds on the two rations was small. In the warm hover the difference in average live-weight increase between the antibiotic-fed and the control groups was not significant, while in the cool pens the corresponding difference was significant at the 5 per cent level of significance.

Thus the antibiotic was most effective when fed in the cool environment.

SUMMARY

Four hundred and forty-four chicks in 11 batches were divided into four groups. In each batch two groups were kept in a "warm" hover and two groups in a "cool" hover. One group from each hover was fed on a basic diet and the other group from each hover was fed on this basic diet supplemented with penicillin. The average live-weight gains of the chicks in the two groups in each hover were compared, and it was observed that in the warm hover the difference in the average live-weight increases between the antibiotic-fed

and the control groups was not significant, while in the cool pens the corresponding difference was significant at the 5 per cent level of significance. Thus the antibiotic was most effective when fed in the cool environment.

ACKNOWLEDGEMENTS

The author wishes to thank Miss M. C. Austin for looking after the chicks and Miss M. J. Francis for technical assistance.

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THE DUTIES OF VETERINARY SURGEONS IN ATTENDANCE AT CHAMPIONSHIP DOG SHOWS

By S. F. J. Hodgman

Animal Health Trust Canine Health Centre, Kennett, Newmarket

Owing to the increase in small animal work, many veterinary surgeons who previously had little to do with the exhibition of dogs are now officiating at championship dog shows. The infusion of new blood is all to the good, but some of the newcomers are not fully informed of the services required of them, or of the scope of their authority; this has led to considerable confusion from time to time.

Veterinary surgeons officiating at dog shows should read *Kennel Club Rules and Regulations*, *Section B*(1) "*Championship Show Regulations*", and *Section F* "*Regulations for the Preparation of Dogs for Exhibition*". These deal with all aspects, conditions, etc., under which dogs may be shown, and they include many rulings that are of particular interest to veterinary surgeons. For instance, in Section B(1), regulation 3 lays down that, among other things, the show executive must make provision for the following:

(d) "At all entrances for dogs, bowls containing disinfectant or soap and water for the use of veterinary surgeons during their examination of exhibits."

(e) "A form of ramp for veterinary inspection at each entrance where dogs are admitted."

(f) "A steward to assist each veterinary surgeon during the examination of dogs entering the show. Each steward shall keep a record of dogs which are refused admission, and shall hand this record to the show secretary."

Regulation 14 deals with veterinary examinations, and reads as follows:

"At least one qualified veterinary surgeon or veterinary practitioner must be appointed to a show other than a sanction show or match. No dog suffering from an infectious or contagious disease shall be allowed to enter or remain in a show.

"The veterinary surgeon, or veterinary practitioner, shall:

(a) Examine each dog at the entrance of the show and if in his opinion the dog (i) exhibits any signs of infectious or contagious disease, (ii) is not entire (an entire dog is one which has both testicles descended and in the scrotum), (iii) is not fit to enter the show from any other cause, he shall refuse it admission to the show and shall report to the secretary of the show the number of any dog to which he has refused admission.

(b) Examine any dog during the show at the request of a judge or a duly

authorized official of the show and if in his opinion the dog should not remain in the show for any reason he shall advise the secretary of the show to arrange its immediate removal.

(c) Examine any dog to which objection has been made on grounds which require veterinary opinion. This opinion must be given in writing to the secretary of the show before the show closes. No dog to which objection has been made may leave the show before such examination.

(d) Examine any dog or dogs at the show when requested to do so, in writing, by the Committee of the Kennel Club.

(e) Every exhibit must be produced to the veterinary surgeon for examination at the entrance of the show.

(f) Once a dog has been refused admission by a veterinary surgeon, it shall not be re-submitted for examination and shall not be permitted to enter the show at any time under any circumstances."

Regulations 16 and 17 state:

16. "*Isolation of Suspicious Cases.* The show committee personally or by their authorized manager of a show shall provide a suitable place in which dogs suspected of contagious or infectious disease can be properly isolated from the rest of the show."

17. "*Exhibition of Dogs suffering from Contagious or Infectious Disease.* If any dog is exhibited which has been exposed to the risk of any contagious or infectious disease during the period of six weeks prior to exhibition and/or if any dog shall be proved to be suffering at a show from any contagious or infectious disease including contagious results of inoculations against distemper, the exhibitor thereof shall be liable to be dealt with under Kennel Club Rule 17."

Under regulation 21(2):

"If it is desired to withdraw a dog from competition through illness, an application to that effect must be made *at once* to the secretary of the show, and if thought necessary by the show committee, the dog examined by the veterinary surgeon of the show. All such cases must be reported to the Kennel Club by the show secretary."

Regulation 27 deals with objections:

"When an objection is lodged, the show secretary must at once require the owner or handler to bring the dog to the secretary's office or any other convenient place appointed by the show secretary, and then advise him of the terms of the objection."

When an objection comes under the terms of regulation 27(b), i.e. improperly tampered with, blind, defective hearing, suffering from any form of contagious disease, or not entire, or under 27(c)—improperly prepared for exhibition, then:

"—the exhibit must not be allowed to leave the secretary's office until it has been examined by the veterinary surgeon and this examination must take place in the presence of the secretary".

On the following day, the show secretary must submit a report to the Kennel Club, including the name and address of the veterinary surgeon who made

the examination, along with a written report from the veterinary surgeon.

Kennel Club Rules and Regulations, Section F "Regulations for the Preparation of Dogs for Exhibition", lay down that:

1. "No dyeing, colouring, tinting, darkening, bleaching or other matter may be used to alter or improve the markings of a dog. Dry white chalk may be used for cleaning, provided that it is removed from the coat before the dog enters the ring. No colouring powder may be applied to the coat of a dog either before or at a show."
2. "No cutting, piercing, breaking by force or any kind of operation or act which destroys the tissue of the ears or alters the natural formation of a dog or any part thereof may be practised and nothing may be done calculated in the opinion of the Kennel Club Committee to deceive, except (a) operations certified to the satisfaction of the Kennel Club Committee to be necessary, (b) the removal of dewclaws of any breed, (c) the shortening of tails of the following breeds: German Shorthaired Pointers, Spaniels (except Irish Water), Airedale Terriers, Australian Terriers, Fox Terriers, Irish Terriers, Kerry Blue Terriers, Lakeland Terriers, Norwich Terriers, Sealyham Terriers, Welsh Terriers, Boxers, Dobermanns, Miniature Pinschers, Old English Sheepdogs, Poodles, Schipperkes, Schnauzers, Miniature Schnauzers, Welsh Corgis (Pembroke), Griffons Bruxellois, King Charles Spaniels, Cavalier King Charles Spaniels, Yorkshire Terriers, Soft-coated Wheaten Terriers."
3. "The setting of the teeth may not be artificially altered."
4. "No oil, greasy or sticky substance which has been used in the preparation of a dog for exhibition shall be allowed to remain in the coat of a dog at the time of exhibition."

Contravention of any of these rulings is, of course, a ground for objection.

These then are the regulations which directly affect any veterinary surgeon officiating at a championship dog show, but it would be helpful to him if he were to read the whole of the sections from which they have been quoted, in order to get a clear understanding of the rules governing both owners and exhibitors.

With regard to equipment, it is not necessary for the veterinary surgeon to take to a show any more equipment than that which he would normally carry when paying professional visits.

An expression of opinion here on the method of examination of entrants may not be out of place, as many veterinary surgeons acting at shows for the first time are not certain how detailed such examinations should be, and some have doubts on exactly what grounds a dog may be refused entry.

It is neither practicable nor necessary to make a detailed clinical examination of every animal; the accumulation of exhibits in the entrance of the show during prolonged veterinary examination may allow the spread of more infection than would be avoided by a thorough inspection. It will certainly cause congestion and bad tempers. Now that stewards are appointed to assist veterinary surgeons, they help considerably to promote the smooth running of things and one of their duties is to prevent a long queue at any one table, by

diverting entrants to tables where there is less congestion. Generally speaking, the stewards are a godsend to the sometimes very harassed veterinary surgeon.

With the exception of the very large breeds, all dogs should be on a table or bench for inspection. It may be desirable to allow the owner to do most of the handling; where it is necessary for the veterinary surgeon to handle the dog extensively, he should bear in mind the owner's feelings as much as possible and avoid giving cause for complaint of such handling. For instance, he should frequently wash his hands, particularly if he has handled a suspicious case beforehand. If, however, the right to make the usual examination is refused, this would justify exclusion of the exhibit.

Examinations of the eyes, gums and teeth, and a glance into the depth of the coat for evidence of gross infestation with parasites are the most useful to carry out. Much can be gleaned from the demeanour and appearance of the dog without undue handling, especially if the owner holds the animal up for examination of the ventral surface and if the head is held so that a general observation of the eyes and nose can be made. Any suspicious case can be detained for more detailed examination later.

Allowance should be made for travel sickness and excitement, which can frequently result in depression, salivation, evidence of vomiting and diarrhoea, and a healthy dog may, under these circumstances, look somewhat dejected.

It is not recommended that the temperature should be taken, or that there should be an examination of the pharynx unless the case is a suspicious one. Where it is necessary to check the temperature, a rise alone should not be the cause for rejection of an animal; such an exhibit should be kept in the isolation kennels provided and the temperature should be re-taken in about half-an-hour's time; if normal, the animal may be passed for exhibit. During the time that a dog is detained for further examination, it is the steward's responsibility to ensure that the animal is not surreptitiously removed to the show benches.

Non-contagious conditions are not necessarily grounds for rejection, neither are enlarged glands unless associated with evidence of active infection, since these may be merely indicative of some past disease. As previously pointed out, it is not practicable to make a thorough examination of every dog entering a show, and such examination should only be carried out in suspicious cases. Even with a cursory examination, a trained eye can detect the animal that is unsuitable for admission.

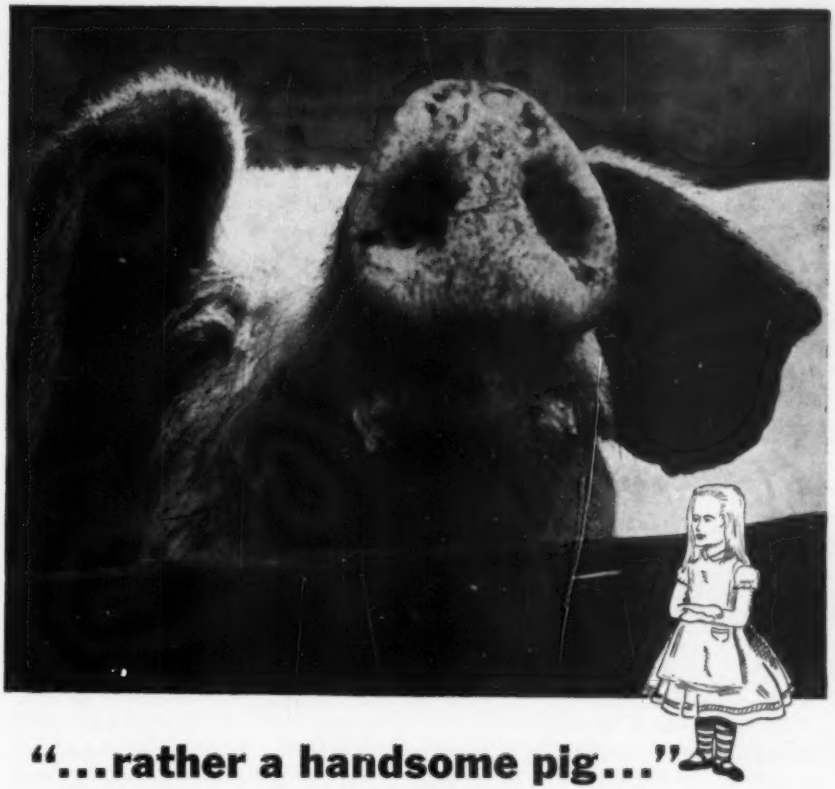
It must be understood that the veterinary surgeon's decision is final, and if he decides that an animal is not fit to enter the show, for whatever reason, then that decision stands. The veterinary surgeon must use his own discretion and he is justified in rejecting even an apparently healthy specimen if it is in such a condition that its exhibition would be detrimental to the general policy of the show.

The very fact that there will be a veterinary inspection of entrants to a championship dog show acts as a deterrent to the unscrupulous exhibitor. The number of dogs refused entry to shows on veterinary grounds is comparatively small, but this does not detract in any way from the value of the veterinary

surgeon's work. In fact, if he were not there, there is little doubt that many undesirable specimens would reach the show benches.

As has been said, it is essential that all veterinary surgeons interested in the exhibition of dogs should acquaint themselves with the Kennel Club regulations applicable to this subject. At one time these regulations were reproduced in the show catalogues, but at present only those rules which affect the exhibits are quoted. Copies of the regulations can, however, be obtained on application to the secretary of a show, or direct from the Kennel Club.

(*Received for publication*, 9 *February* 1961)



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BOOK REVIEWS

Reproduction in the Dog. A. E. HARROP. 208 pp. text, 32 pp. plates. London: Baillière, Tindall and Cox. 30s.

The author has made a successful attempt to produce a practical volume suitable for all interested in reproduction in the dog. There are five excellent contributions by men well qualified to write on their subjects. It is inevitable that there should occur a little overlapping, but this in no way detracts from the value of the book. In its 197 pages of easily read contents and well presented photographs, the author himself writes lucidly and with experience to fill the body of the book. The sequence of the various articles has been well arranged and all who have dog breeding at heart will welcome this little book and praise the author for producing it. References are freely given for those who want to delve deeper into the literature, but those who do not will still find many well-marshalled facts and copies of the book will be found on the bookshelves of many small animal practitioners. Much praise is due to Mr. Harrop and his professional colleagues for this happy result of their co-operation.

J. K. BATEMAN

Die Erbschäden der landwirtschaftlichen Nutztiere (*Inherited defects in agricultural animals*). BY EKKEHARD WIESNER. pp. 186. Jena: Gustav Fischer.

Veterinarians and stock breeders frequently encounter genetic abnormalities of livestock. There is a large literature on such defects but it is, unfortunately, scattered over many journals. We are, therefore, indebted to those who labour to assemble and summarize the work. Foremost in this field recently have been German authors. In 1957 appeared "Erbpathologie der landwirtschaftlichen Haustiere" by Koch, Fischer and Schumann. Now we have "Die Erbschäden der landwirtschaftlichen Nutztiere" by Ekkehard Wiesner.

Professor Wiesner's slim volume describes and gives references to many defects in different species of livestock. It has opening chapters on the significance and mode of inheritance of defects. It is, as such books should be, well illustrated.

The book, however, has many shortcomings. There is an almost total lack of reference to population genetics. We are told little or nothing of how a gene is likely to spread through a herd, a breed or an artificial insemination system, or what measures should be adopted to control genetic defects. The list of defectives is also far from complete. There is, for example, no reference to the American dwarf beef cattle. The latest reference to genetic factors influencing foetal mortality in pigs is dated 1923. The book is also unbalanced. Cyclopia, a very rare condition in livestock, is treated to a page, whereas early embryonic mortality is dismissed in a few lines. Much of the inadequate and unsatisfactory genetics of the original papers is also accepted uncritically.

Despite its superficial nature, the book is to be welcomed. Genetic defects are assuming greater significance in veterinary science, and any work which stimulates interest is at least on the right lines.

G. B. YOUNG

NEWS

NATIONAL ESSAY COMPETITION

Minsal Limited has decided to institute an annual National Essay Competition for veterinary students.

The competition is open to all veterinary students in Great Britain who will complete the course in Animal Nutrition during the current academic session.

The subject for 1961 is "Hypomagnesaemia in Ruminants" and the closing date for entries is 30th September, 1961.

The examiners will be two Heads of Departments from Veterinary Schools and a representative of Minsal Limited.

The following prizes will be given:

1st	50 gns.
2nd	20 gns.
3rd	10 gns.

The completed essays should be submitted to Mr. J. Cassidy, Minsal Limited, Victoria Works, Wincham, Northwich, Cheshire. The candidate's name should *not* appear on the paper but should be given in a covering letter.

FORMATION OF EXPERT PANEL ON VETERINARY EDUCATION JOINTLY BY THE FOOD & AGRICULTURE ORGANIZATION AND THE WORLD HEALTH ORGANIZATION

It will be recalled that an International Meeting on Veterinary Education, convened by the Food and Agriculture Organization of the United Nations, took place in London in April 1960 and was attended by delegations from 40 countries and observers from 18 national and international organizations and countries. Probably the most important recommendation of the meeting was the invitation to the Director-General of FAO to establish an international panel on veterinary education jointly with the World Health Organization "to study all details concerned with veterinary education in the various regions of the world".

The panel has now been established and consists of the following members: Professor C. Bressou, France; Dr. El Nazir Defaalla, Sudan; Dr. R. M. C. Gunn, Australia; Dr. William A. Hagan, United States of America; Dr. T. Lloyd Jones, Canada; Professor S. R. Numans, Netherlands; Dr. T. Ramos Saco, Peru; Dr. R. Rastegar, Iran; Sir John Ritchie, United Kingdom; Dr. L. Sahai, India, and Professor J. Jansen, World Veterinary Association.

As and when necessary other members will be added to the panel.

The members of the panel were nominated in such a manner as to provide geographical representation of the different regions of the world.

The initial work and investigations will be conducted mainly by correspondence. Information will be correlated at FAO headquarters and circulated to panel members and co-operating bodies all over the world. The work

of the panel has begun with the consideration of a draft programme of work prepared by FAO and WHO.

The members of the panel will provide expert information and advice on the many subjects to be dealt with, to foundations and other bodies interested in supporting veterinary education. In this work they will consult colleagues in the various world regions. Views and opinions will thus be forthcoming from many sources.

The panel will meet early in 1962, when the collected material will be reviewed and a beginning made with agreed recommendations.

The Animal Health Branch of FAO will provide organizing and secretarial services for the work of the panel, and will welcome reports, comments and information from interested individuals, professional associations and other bodies.

MORE MONEY ALLOTTED TO FIGHT AFRICAN HORSE SICKNESS —NEW OUTBREAKS OF DISEASE REPORTED FROM INDIA AND JORDAN

An additional $30,000 has been granted to FAO from the United Nations Technical Assistance Board's contingency fund, to further the production of vaccine to combat African horse sickness, the Food and Agriculture Organization announced recently.

The grant will be distributed by FAO among national laboratories already engaged in the production of the vaccine. Laboratories in India, Pakistan, Afghanistan, Turkey, Greece, the United Arab Republic, Iraq and Iran are expected to be among those to benefit from the new grant.

The money will be used to supply equipment, mice used in the manufacture of the vaccine, and also to send an expert to service the freeze-drying equipment used in the production of the vaccine.

News of the latest allocation from the United Nations Technical Assistance Board, which supplied $185,000 to FAO last year to combat horse sickness, coincided with the report that 200 cases of this highly-contagious equine disease broke out in India this month. Some cases were also reported from Jordan.

REPORT ON THE ANIMAL HEALTH SERVICES IN GREAT BRITAIN 1959

The Report on the Animal Health Services in Great Britain for 1959* shows that, so far as outbreaks of notifiable diseases were concerned, the year was overshadowed by the worst epidemic of fowl pest ever known in this country. The 2,062 outbreaks resulted in the slaughter of nearly five million birds and the destruction of close on one million hatching eggs. The foot-and-mouth disease position improved, however, and the number of outbreaks was the

* The Report on the Animal Health Services in Great Britain, 1959, published by H.M.S.O. price 6s. od. net (by post 6s. 6d.).

lowest since 1955. During the course of the year, Scotland and Wales became Attested Areas and in Great Britain as a whole 95 per cent of all cattle had reached attested status and since the report was prepared the whole of Great Britain has been declared fully attested.

The Report, published on March 30, explains the methods used to restrict the introduction and spread of animal disease in Great Britain. It gives results of experiments undertaken to diagnose, control and eradicate animal disease. Information is also given about exports of livestock and various products, and the protection afforded to animals during transit.

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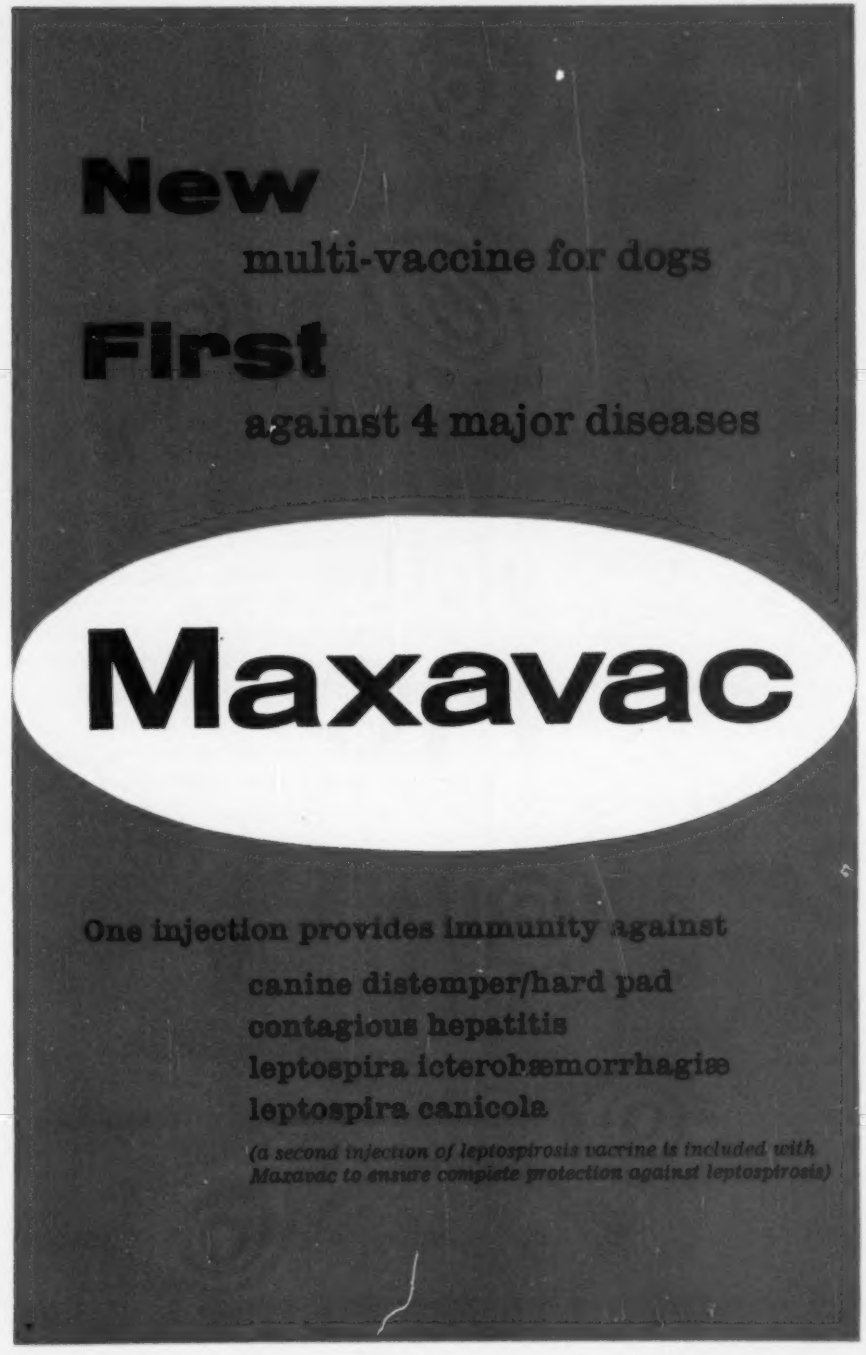
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THE BRITISH VETERINARY JOURNAL

The June issue (Vol. 117, Number 6) will contain the following papers:

I. W. Parnell, A. M. Dunn and G. M. Mackintosh *Animal Diseases Research Association, Moredun Institute, Gilmerton Edinburgh.*	Field trials of some anthelmintics on Scottish Hill Ewes.
M. P. Johari and P. C. Gangwar *College of Veterinary Science & Animal Husbandry, Mathura, India.*	The Technique of Vasectomy (Vasoligation) in Cattle and Buffaloes.
J. K. Bateman *Greyhound Racing Association, The Hook Kennels, Northaw, Potters Bar, Middlesex.*	Greyhound Racing—Duties of the Veterinary Surgeon at tracks.
B. L. Nestel *Livestock Division, Research Dept. of the Sugar Manufacturers' Assoc. Jamaica.*	A note on the effects of Chlorpromazine injections at weaning on the subsequent live-weight gains of Beef Calves of both European and Zebu Breeding.
T. M. Doyle *Central Veterinary Laboratory, Weybridge.*	African pig diseases.

NOTICE TO CONTRIBUTORS

1. *The British Veterinary Journal* publishes original papers and reviews on all aspects of veterinary science and kindred subjects. Accounts of clinical observations are published and, in the form of letters to the editor, preliminary reports of scientific studies. Reviews should, in general, be written in support of original investigations.

2. *Manuscripts*, written in the English language, should be sent to the Editor, *The British Veterinary Journal*, 7 and 8 Henrietta Street, London, W.C.2. Papers are accepted for publication on the understanding that they have not been published and are not being considered for publication elsewhere, and that they may not be re-published without sanction from the publishers.

3. Contributions, which may be subject to editorial revision, should be condensed as far as possible and should be submitted as a top typewritten copy on one side of the paper only, with double spacing and ample margins. The spelling should be that of the Oxford English Dictionary.

4. Manuscripts should be headed with the title of the paper, the name and postal address of the author or authors, or, where applicable, the address of the institution where the work was done. They should conclude with a factual summary equal to about 3 per cent. of the length of the paper. References to previous work should be cited in the text with the author's name and the year of publication in parentheses, e.g., "Brown (1957) showed that . . ." Where there are more than two authors the names of all should be cited on the first occasion in the text and thereafter only the first followed by *et al.*, e.g., "Brown *et al.* (1957) . . ." In the list of references at the end of the paper all the authors' names and initials should be included. The references should be listed in alphabetical order of the surnames of the authors, and the titles of the journals should be abbreviated in accordance with the *World List of Scientific Periodicals*, e.g., Brown, A. B. (1957) *Brit. vet. J.*, **113**, 217.

5. *Illustrations* should be numbered in arabic numerals in the order in which they appear in the text and all referred to as "figures," and should be somewhat larger than the size desired for reproduction. Drawings, diagrams and graphs should be in black ink on Bristol board or stout, smooth white paper. Letters and numbers should be indicated on them lightly in pencil. Photographs and photomicrographs should be printed on glossy paper. X-ray films should not be submitted, but prints of them, preferably negative prints. The areas to be reproduced of the photographic illustrations, if less than the whole, should be outlined *lightly* in pencil on the back of each. All illustrations, diagrams, etc., should bear on the reverse side the author's name, a short title of the paper and a figure number. Legends should be typed on a separate sheet of paper and should not be attached to the illustration. A statement of the magnification of illustrations should be given where it is applicable.

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